VOL. 12, No. 2 FEBRUARY, 1935

Medical Library
610.5
A5
J86
065
v.12
no.2

The AMERICAN JOURNAL of OPTOMETRY

EDITORS

CAREL C. KOCH JACK I. KURTZ

COLLABORATORS

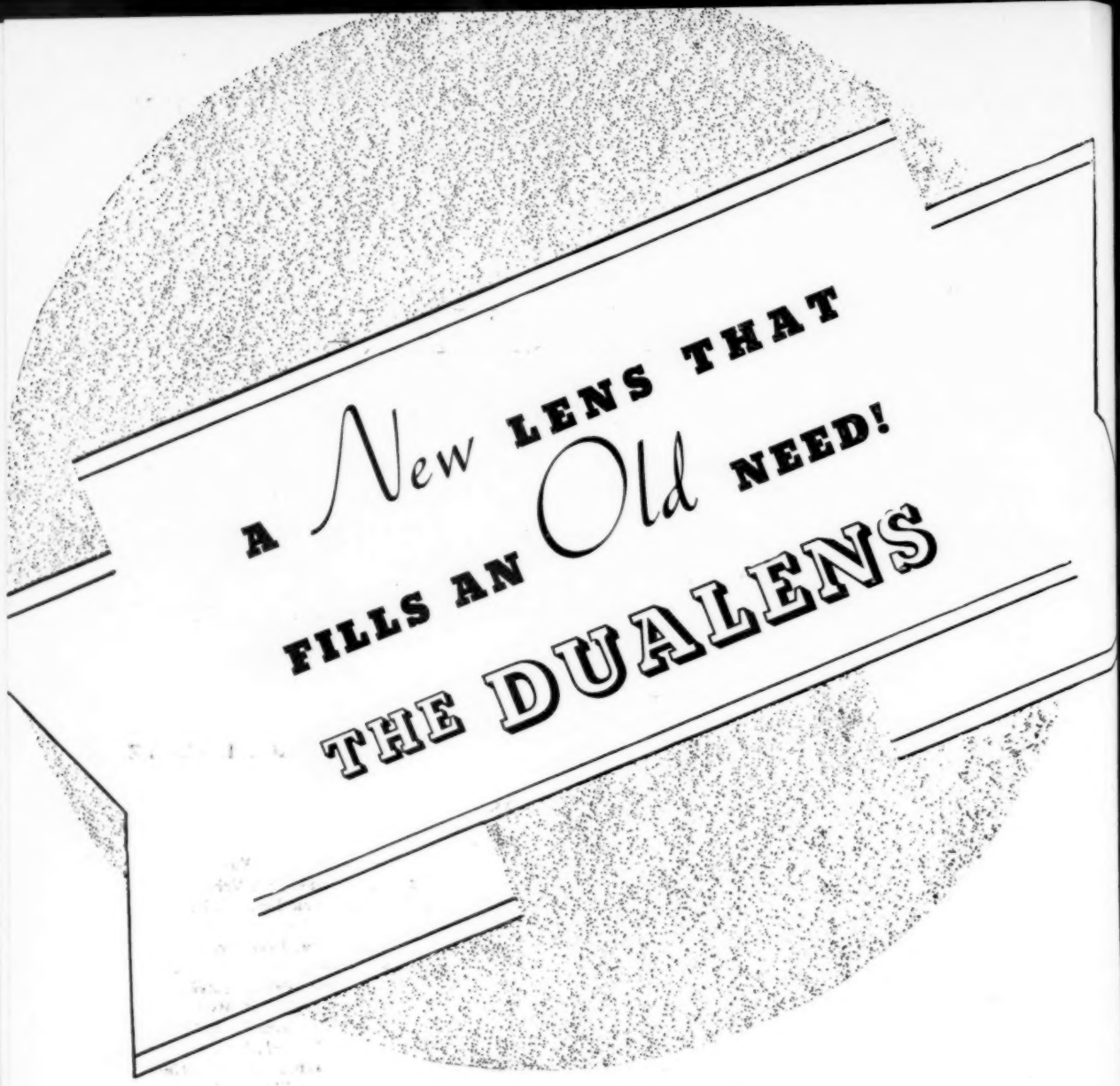
E. B. Alexander, *Duncan, Okla.*
J. Fred Andreae, *Baltimore, Md.*
J. O. Baxter, Sr., *New Bern, N. C.*
L. L. Beacher, *New York, N. Y.*
O. E. Bell, *Fairmount, W. Va.*
Robt. T. Best, *Fairmont, Minn.*
W. I. Brown, *New Bedford, Mass.*
J. T. Campbell, *Washington, N. C.*
R. G. Colberg, *Aberdeen, S. D.*
Paul Dill, *Greeley, Colo.*
H. C. Doane, *Boston, Mass.*
J. H. Drakeford, *New York, N. Y.*
G. L. DuPlessis, *Minneapolis, Minn.*
T. H. Eames, *W. Somerville, Mass.*
W. S. Farmer, *Oklahoma City, Okla.*
Wm. Feinbloom, *New York, N. Y.*
L. P. Folsom, *South Royalton, Vt.*
H. L. Fording, *Portland, Ore.*
F. W. Freeman, *Anderson, Ind.*
M. Gilbert, *Owosso, Mich.*
W. H. Glazer, *Philadelphia, Pa.*
R. M. Hall, *Cleveland, Ohio*
C. H. Hathaway, *Pontiac, Mich.*
C. K. Haynes, *Jamestown, N. Y.*
A. E. Hoare, *Los Angeles, Calif.*
B. T. Hoffman, *Chicago, Ill.*
H. S. Horton, *Cleveland, Ohio*
E. E. Hotaling, *New York, N. Y.*
C. E. Jaeckle, *Newark, N. J.*
Chester Johnson, *Philadelphia, Pa.*
H. D. Judd, *Detroit, Mich.*
B. E. Kehl, *St. Louis, Mo.*
L. H. Kraskin, *Washington, D. C.*
N. Levin, *Chelsea, Mass.*
R. E. Littlefield, *Kansas City, Mo.*
J. J. Livingston, *Little Rock, Ark.*
C. V. Lyons, *San Francisco, Calif.*
G. A. MacElree, Jr., *Phila., Pa.*
F. L. Mason, *Berkley, Calif.*
D. J. Mayer, *Riverside, Calif.*
O. L. McCulloch, *Holyoke, Mass.*
Wm. Mendelsohn, *Chicago, Ill.*
F. McFadden, *Rutland, Vt.*
O. J. Melvin, *Omaha, Nebr.*
M. B. Meyer, *Wilmington, Del.*
J. K. Morris, *Erie, Pa.*
J. C. Neill, *Philadelphia, Pa.*
J. Neumueller, *Philadelphia, Pa.*
M. M. Ocshier, *W. Springfield, Pa.*
G. Oertel, *Syracuse, N. Y.*
G. O. Ohlsson, *Detroit, Mich.*
C. R. Padelford, *Fall River, Mass.*
D. R. Paine, *Topeka, Kan.*
Geo. A. Parkins, *Ord, Nebr.*
J. I. Pascal, *New York, N. Y.*
R. J. Pearce, *Greensboro, N. C.*
R. M. Peckham, *Rochester, N. Y.*
Ernest Petry, *Rochester, N. Y.*
S. H. Robinson, *Prescott, Ariz.*
A. N. Prussin, *Detroit, Mich.*
E. LeRoy Ryer, *New York, N. Y.*
H. L. Salov, *Newark, N. J.*
Charles Sheard, *Rochester, Minn.*
Carl Shephard, *Chicago, Ill.*
R. E. Simpson, *Pasadena, Calif.*
W. Smith, *Dorchester, Mass.*
H. R. Spitler, *Eaton, Ohio*
M. J. Stark, *Union City, N. J.*
M. Steinfeld, *Paducah, Ky.*
Edwin Forbes Tait, *Phila., Pa.*
H. Thomas, *Wenatchee, Wash.*
S. S. Titus, *Kansas City, Mo.*
R. N. Walker, *Winston-Salem, N. C.*
A. P. Wheelock, *Des Moines, Iowa*
A. C. Whitaker, Jr., *Bridgeton, N. J.*
E. G. Wiseman, *Buffalo, N. Y.*
A. T. Wray, *Los Angeles, Calif.*
L. K. Wyatt, *Peoria, Ill.*

Published Monthly by the American Journal of Optometry Publishing Association,
1501 Foshay Tower, 821 Marquette Ave., Minneapolis, Minn.

ANNUAL SUBSCRIPTION $4.00. CANADA AND FOREIGN $5.00

Entered as second-class matter February 20, 1924, at the postoffice at Minneapolis, Minnesota, under the Act of March 3, 1879.

UNIVERSITY OF MICHIGAN
MEDICAL LIBRARY



NATION-WIDE reports indicate that the Dualens is winning almost universal endorsement. But that is not as surprising as it might seem, because the evolution of the Dualens has been the result of the expressed need for such a lens by a large number of the country's leading refractionists. They asked for a white lens with the added feature of peripheral glare protection. They have it, with even additional advantages, in the Dualens, which every ethical refractionist can now prescribe.

To clearly define its logical place in the field of ophthalmic optics, the Dualens does not provide all-over absorption for patients whose eyes are sensitive to light in the direct field. They are or should be wearing Soft-Lite lenses and securing the benefit of complete glare protection. Rather, it is for the others—that the Dualens is ideally suited. For those patients who ordinarily would wear white lenses the Dualens is superior in both performance and appearance.

The soft tinted margin reduces peripheral glare and internal reflections. It also practically eliminates the annoying and conspicuous "edge glitter." The clear center transmits all the light for direct field vision.

The Dualens is a masterpiece of optical craftsmanship and, on the face, it's the most inconspicuous of all spectacle lenses. What's more, from an economic viewpoint, the Dualens has a visible difference which, with its controlled distribution, makes for a product of inestimable value to you. Write for the free new booklet on the Dualens. Address your request to your wholesaler or to the Soft-Lite Lens Company, 119 West 57th Street, New York City.

ERFORMANCE, PRESTIGE, PROTECTION AND PROFIT WITH THE DUALEN

AMERICAN JOURNAL OF OPTOMETRY

VOL. 12 FEBRUARY, 1935 No. 2

CONTENTS

ORIGINAL PAPERS

Cautions concerning Illumination Intensities used for reading. Miles A. Tinker 43

Considerations regarding the analysis and interpretation of data on ocular Convergence and Accommodation. Part IV, Charles Sheard 52

A study of the Factors Entering into the determination of Handedness. Introducion, Part 1 and Part II. Lewis H. Kraskin 62

An ocular diagnosis for Intestinal Auto-Intoxication. Russell E. Simpson 74

Duochrome-Cross Cylinder Check Test. William Smith 80

EDITORIALS

Massage and the correction of Ocular Symptoms 82

The Röntgen or X-Rays 83

WHICH BIFOCAL?
AND WHY?

A number of questions confront the refractionist each time he prescribes bifocal lenses. Which bifocal should be used? Why?—How high should the segments be? How much inset?—Should the lens be tilted? How much?—How far from the eyes should the lens be? The comfort and efficiency of the bifocals depend almost as much on the correct answering of these questions as on the correctness of the refraction.

WALCO BIFOCAL SERVICE

You may have these questions answered accurately and scientifically by using the Walco Bifocal Service. Here's how to do it. Send us a full and detailed prescription. We will analyze your prescription and return to you a complete report covering the above questions. The report will be unbiased. This service is free to refractionists, in the territories we serve, and details no obligation. Use it whenever there is the slightest doubt about bifocal lenses.

THE WALMAN OPTICAL COMPANY
229 MEDICAL ARTS BLDG.
MINNEAPOLIS, MINN.

FARGO GRAND FORKS ST. PAUL

AO
AMERICAN

AMERICAN JOURNAL OF OPTOMETRY

VOL. 12 FEBRUARY, 1935 No. 2

CAUTIONS CONCERNING ILLUMINATION INTENSITIES USED FOR READING*

Miles A. Tinker, Ph.D.
University of Minnesota
Minneapolis, Minnesota

Comfortable, healthful and efficient functioning of the eyes in the reading situation is of concern to all after the first few years of life. Since a large amount of one's reading is ordinarily done under artificial illumination, lighting practice assumes a place of prime importance. Faulty illumination frequently leads to eyestrain which is often accompanied by reflex functional disturbances of other organs. Economy and artistic effect of lighting are of purely secondary importance in comparison with the conservation of eyesight. Furthermore, illumination efficiency cannot be divorced from visual function.

One of the more important factors to be considered in prescribing hygienic lighting for the reading situation is brightness or intensity[1] of illumination. Although the more technical reports on lighting are in the scientific journals, it is mainly from other sources of information that the general public is being made conscious of illumination intensities: (1) The source for much of the material stressing the needs for higher intensities of light is *The New Science of Lighting* (12) by Luckiesh and Moss of the General Electric Lighting Research Laboratory. (2) Many popular discussions of the subject printed in various non-technical magazines (5, 10, 11). Practically all of these have been inspired by *The New Science of Lighting.* (3) In an effort to promote more adequate illumination in the home, office, and factory, a lighting analysis service is furnished by some power companies.

In these sources of information, emphasis is placed upon the need of relatively high intensities of artificial illumination if hygienic vision is to be maintained. In the more popular discussions (5, 11) a minimum of 25 foot-candles is recommended. A light-measuring tape furnished by "Good Housekeeping" specifies distances from the lamp which yield

*An abridgment of the material presented before the Minnesota Academy of Optometry at the University of Minnesota, September 18, 1934.

[1] For a general discussion of illumination and the hygiene of reading see Tinker (14).

25 foot-candles as adequate illumination. Luckiesh (10) and Luckiesh and Moss (12) specify the following: 100 foot-candles or more for discrimination of fine details: 50 to 100 foot-candles for difficult reading; 20 to 50 foot-candles for ordinary reading; 10 to 20 foot-candles for ordinary reading for short periods; 5 to 10 for casual seeing not involving reading or other fine discrimination; below 5 foot-candles is the danger zone for visual discrimination. These recommendatons are, in general, three or more times higher than those previously made by the Engineering Department of the General Electric Company (6).

Tinker (14) has surveyed the material on illumination intensity in relation to practical reading situations. For artificial illumination the trend of results may be briefly stated: There is a marked decrease in ability to sustain clear seeing (fatigue) due to continuous reading for three hours under diffused illumination of less than one foot-candle, but this fatigue disappears at three foot-candles and above. Measurement of speed of reading showed a similar trend. Illuminations of below three foot-candles slowed the speed of reading but there was no retardation at three foot-candles and above. There occurred no change in efficiency in a short number-work test when the illumination was increased by steps from 9.6 to 118 foot-candles. Letter sorting by postoffice employees reached its maximum speed only when the illumination was at least eight foot-candles. These results would seem to indicate that illumination intensity need not exceed 10 foot-candles to produce efficient and comfortable functioning of the normal (emmetropic) eye. In fact it may be somewhat less than 10 foot-candles without reaching the danger zone.

We may raise at this place two questions: (1) Are the high intensities recommended by Luckiesh and Moss (12), and others necessary to achieve adequate hygienic illumination? (2) May the use of high intensities result in harm to the eyes? We may tentatively say that the high intensities are not necessary and that under certain conditions they may produce eyestrain.

Examination of Luckiesh and Moss' "The New Science of Lighting" (12) shows that they base their argument for the high intensities mainly upon (1) their study called *A Correlation Between Illumination and Nervous Muscular Tension Resulting from Visual Effort* (9), and (2) preferences for light intensities that seem comfortable to the reader (7, 8, 9). In the first study, which they call the most significant research so far reported in the invasion of the realm of psychophysiological effects of seeing, and which they claim is mainly responsible for establishing a "new science of lighting," they measured "nervous muscular tension" during reading. The method consisted "in measuring the changes in muscular tension as registered by the fingers of the left hand which rested naturally and lightly upon the knob of a concealed key" while the subject read under 1, 10 and 100 foot-candles of light. The pressure on the knob was registered in grams. The mean results for 14 subjects were: 63.2 grams for 1 foot-candle, 54.1 grams for 10 foot-candles and 43.0 grams for 100 foot-candles. There was no significant change

in rate of reading from one illumination intensity to another. On the basis of these results the authors claim (12) that "at least several hundred foot-candles would be the best intensity of illumination for this task which could be performed in full moonlight." Keeping in mind that these conclusions are for the reading of fairly large (12 point) type on excellent book paper by the normal eye, one may question the validity of the authors' interpretation even though the method of measurement is assumed to be adequate. There is some question concerning the adequacy of the method.

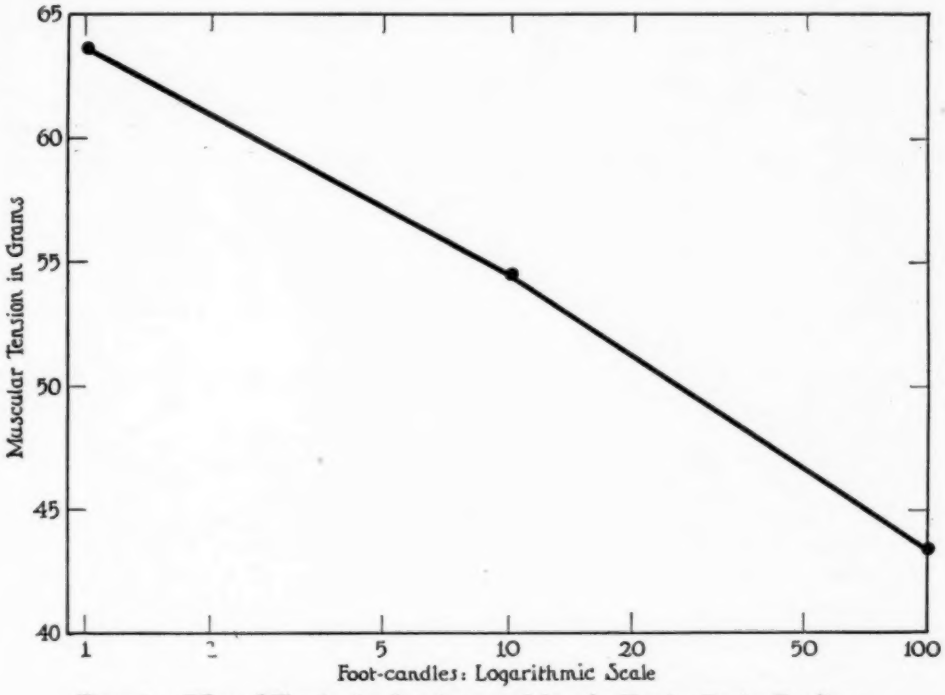


Figure 1. Effect of Illumination Itensity upon Muscular Tension During Reading: Lo ithmic Scale (constructed from Luckiesh and Moss' Data, p. 584, ref. 9).

Let us examine their results more in detail. They present the data in graphic form with foot-candles on a logarithmic scale as in Figure 1. It is pointed out that the curve is approximately logarithmic in character and similar to the relationship existing between intensity of illumination and certain variables which influence visibility. It is, for instance, quite similar to that expressing the relation between visual acuity and illumination intensity which is approximately logarithmic in character (13).

Plotting data of this kind on a logarithmic scale may, however, lead to misinterpretation, especially by the unsophisticated and the uncritical reader. The curve in Figure 1 might seem to indicate that the changes in muscle tension at the higher intensities were marked and

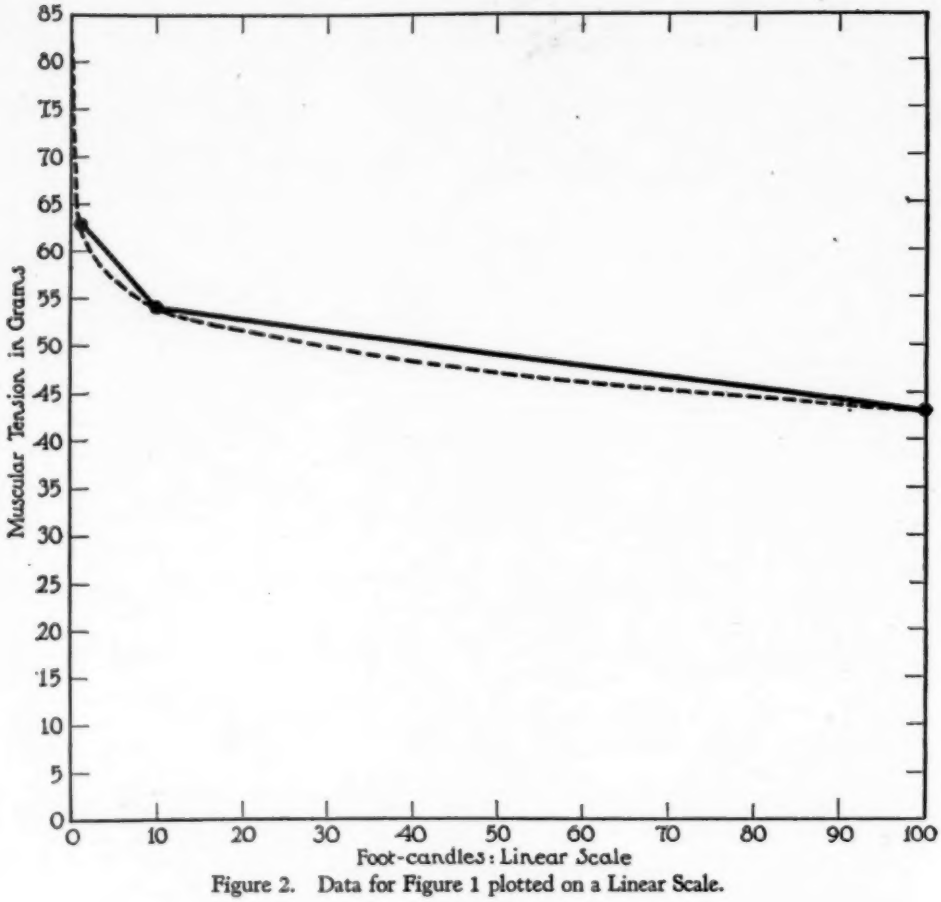


Figure 2. Data for Figure 1 plotted on a Linear Scale.

actually significant from the practical viewpoint. Furthermore, a graph constructed on the scale used by the authors magnifies minute differences so that they appear large. The fallacy of the impression gained from Figure 1 is apparent when it is compared with Figure 2 where the same data is plotted in proper proportions (the whole scale is present in the graph) on a linear scale and smoothed (dotted line). This curve for change in muscular tension with variation in light intensity approximates the curve for relation of visual acuity and illumination intensity (upside down) (13). The changes in muscle tension are very rapid from a fraction of a foot-candle to about 5 foot-candles, moderately rapid from 5 to 10, very gradual from 10 to 20 or 25, and very slow thereafter. That is, most of the change (probably all that is of practical importance) in muscular tension occurs at relatively low illumination intensities. There is no more justification in concluding from these curves that high (25 or more foot-candles) light intensities are desirable and necessary

for ordinary reading than it is to draw a similar conclusion from the relation between visual acuity and illumination intensity. It is obvious that Luckiesh and Moss' interpretation that these slight changes in muscle tension indicate that several hundred foot-candles are best for reading large black print on white paper cannot be accepted as valid. The data merely confirm earlier findings that ease and proficiency of reading by the normal eye increases with increases of illumination intensities up to about 8 or 10 foot-candles in the ordinary reading situation. The slight changes that occur above this level have not been proved to be of practical significance.

What intensity of light do readers prefer? Luckiesh and Moss (12) had 82 subjects select a light intensity solely on the basis of comfort afforded by the lighting. Up to 1000 foot-candles were available. Unfortunately, the authors do not state the illumination to which the eye was adapted, nor do they say whether the illumination was local or general. Both these factors have an important bearing upon the validity of their results. The distribution of preferences was: 11 per cent at 10 foot-candles, 18 at 20, 32 at 50, 20 at 100, 17 at 200, 1 at 500, and 1 at 1000. They state that subjects choose an average of about 100 foot-candles to read by when they have the opportunity, and continue to speak of this intensity as the most representative value for the group. In a distribution with atypical cases (as one subject at 500 and one at 1000 foot-candles far off to one side) statistical practice demands that the median rather than the average be used as a measure of central tendency, or that the atypical cases be omitted before computing the average. In an earlier publication (7) Luckiesh, Taylor and Sinden themselves state in a similar experiment that "the median has the advantage of not giving undue weight to observations which are far from the average," and that values which deviated greatly from the average were omitted from the summary. Since both the median and the mode are at 50 foot-candles in Luckiesh and Moss' data (12), this value rather than 100 should be taken as most representative of the group trend. It is obvious that 100 is not a representative central tendency since only 19 per cent of the cases lie above it while 61 per cent lie below it.

In another report Luckiesh (11) states that a large number of observers preferred on the average 370 foot-candles of light for comfortable reading. This value has no validity whatever since the subjects were obviously adapted to daylight illumination and the illumination was local. The subject viewed the illuminated page of a telephone directory (very illegible material) through a small door in a black box. Results from such an experiment can have no bearing on the hygiene of artificial illumination.

Results obtained in earlier experiments seem more adequate. Under favorable conditions of light distribution and with general illumination of the room by gas-filled tungsten lamps. Luckiesh, Taylor, and Sinden (7) found that on the average readers preferred 5.3 foot-candles for reading large type (11 and 12 point), and 10.6 to 16.1 for medium

sized type (9 point). For a low degree of contrast between 9 point type and paper only 17.4 foot-candles were chosen when 30 were available. In a later study Luckiesh and Taylor (8) obtained preferences for intensities of illumination when reading medium sizes type (9 point in Saturday Evening Post) under gas-filled tungsten lamps. The illumination was general and well distributed. With 8 foot-candles available, the readers chose 4.2, with 30, 10.6, with 45, 16.1, with 65, 23.2, with 100, 35.8. The authors conclude that the subjects did not choose the maximum because they probably assumed that the desired intensity was somewhere between the extremes. This conclusion is obviously wrong for two reasons: (1) In the later study (12, cited above) a median intensity of only 50 foot-candles was chosen when 1000 foot-candles were available and the subjects made their selection solely upon the basis of their own criteria of comfort afforded by the lighting and with no possible suggestion that this would fall between the extremes. (2) In all cases, except for 8 foot-candles, only about one-third of the available intensity was chosen. In the later experiment (12) only one-twentieth of the available brightness was selected as best suited for comfortable reading. The surprising fact is that such low intensities were chosen when more light was available. Even when 8 foot-candles are available the reader prefers only one-half that amount (4.2 f.c.) for comfortable reading. It seems rather obvious that the explanation is in terms of the adaptation of the eye. The eye readily adapts itself to easy and efficient seeing at the various intensities of illumination above a certain minimum. For ordinary reading by the normal eye this minimum seems to be approximately 3 foot-candles (14). When the eye is subjected to a range of intensities as in Luckiesh and Taylor's experiment, adaptation is apparently such that about one-third the available brightness is chosen as most comfortable for reading whether 30, 45, 65, or 100 foot-candles are available. Since the range of intensities available in most homes and offices is probably not greater than 8 to 30 foot-candles, we can take 4.2 to 10.6 foot-candles as representative values for preferred light intensities in these situations. Contrary to Luckiesh and Moss' conclusions (12), therefore, there is nothing in the literature to support the notion that the normal person reads with greater comfort under relatively high intensities of illumination.

This does not mean that high intensities of light are never needed. Certain situations demand a somewhat higher than ordinary light intensity for effective seeing. In some instances 100 or more foot-candles are desirable. (1) The defective eye needs a higher light intensity than the normal eye to achieve the same degree of effective vision. This is true even though corrective lenses are worn (14). In a like manner the middle-aged and the old eye need more light than the young eye. Ferree, Rand and Lewis (3) show that, comparatively speaking, the normal eye receives little benefit from intensities above 10 foot-candles while presbyopes are markedly aided by intensities up to 100 foot-candles. They suggest that the grading of intensity to meet the age requirement is

perhaps the major problem in the use of intensity in lighting practice. In another study Ferree and Rand (2) show that near point vision of presbyopic eyes is markedly influenced by increased light intensity in contrast to the slight effect on non-presbyopic eyes. They suggest that intensity of light as well as correcting glasses should be kept in mind as one of the aids in presbyopia. (3) When small print is to be read, when there is relatively small contrast between print and paper, or when any printing arrangement provides less than optimum legibility the illumination intensity should be increased (14). (4) In any situation which demands discrimination of very fine details the light intensity should be relatively high.

The relation between intensity and distribution of light in any seeing situation is extremely important. It has been frequently emphasized that the most fundamental aspect of hygienic illumination and the one most frequently inadequate, is the distribution of light in the field of vision. Any increase in light intensity which produces an increase in glare (excessive brightness of the light source, excessive brightness contrast, lateral illumination, etc.) produces an unhygienic lighting situation and may result in marked eyestrain. With well diffused indirect lighting (14) the intensity may be increased to any desired level without harm to the eyes, but with direct and indirect systems where the light is not well diffused (14) the higher intensities result in increased glare and should be avoided. If print paper is glazed or shiny, glare becomes more annoying as the intensity of light which is not well diffused is increased. The paper in many magazines and books has varying degrees of gloss, and the light in the majority of living rooms and offices is not well diffused. Consequently, increase of light intensity usually means increased glare in the reading situation. Although some of the articles (5, 10, 11) which recommend high (25 or more foot-candles) intensities of light for ordinary reading mention the desirability of maintaining good distribution of light, none mention this extremely important relation between distribution and intensity of light as related to eyestrain. Great harm can come to the eyes of readers who follow the directions to use very bright lights unless the distribution of light is such that glare is not enhanced when the light intensity is increased. It is highly probable that, with the best diffusion available in the ordinary home and office, the light intensity should not be higher than about 15 foot-candles. To avoid glare effects Ferree and Rand (1, 4) have designed two excellent lighting units which yield hygienic glareless illumination.

What intensities of illumination are to be recommended? If we keep in mind both preference for light intensities and the requirements for efficient and easy seeing, the following specifications should fulfil the requirements of hygienic vision for the reading of legible print by the normal eye: (1) for direct lighting with poor distribution, 3 to 5 foot-candles; (2) for combinations of direct and semi-indirect illumination frequently found in homes, 5 to 10 foot-candles; (3) for the better degrees of light distribution found in some homes and offices, 10 to 15

foot-candles. If glare can be avoided, higher intensities may be employed without harm, but also without practical advantage to the normal eye. With abnormal eyes, with print of less than optimal legibility, and for discrimination of fine details the light intensities should be much higher. Eyestrain cannot be avoided unless the light is adequately diffused at these higher intensities.

Summary and Conclusions

There is no valid evidence in the literature to support the suggestions that the normal eye needs from 25 to several hundred foot-candles of artificial illumination for easy and efficient reading of legible print. Furthermore, analysis of the data on preferred intensities indicates that the eye selects a relatively low intensity for comfortable reading when the eye is adapted to the brightness usually found in artificial lighting. The intensity of light permissible is directly dependent upon the uniformity of diffusion present. Any increase of illumination intensity which increases glare is unhygienic and leads to eyestrain. For all but abnormal eyes and the reading of illegible print, 10 to 15 foot-candles furnish an ample margin of safety in brightness of illumination. Where the distribution of light is poor, as it is in many situations, lower intensities are more hygienic.

DR. MILES A. TINKER
DEPARTMENT OF PSYCHOLOGY
UNIVERSITY OF MINNESOTA
MINNEAPOLIS, MINN.

REFERENCES

1. Ferree, C. E., and Rand, G. Glareless lighting for hospital wards. The Modern Hospital, June, 1932, 1-4.
2. Ferree, C. E., and Rand, G. The effect of intensity of illumination on the near point of vision and a comparison of the effect for presbyopic and non-presbyopic eyes. Trans. I. E. S., 1933, 28, 590-611.
3. Ferree, C. E., and Rand, G., and Lewis, E. F. The effect of increase of intensity of light on the visual acuity of presbyopic and non-presbyopic eyes. Trans. I. E. S., 1934, 29, 296-313.
4. Ferree, C. E., and Rand, G. A new principle in hygienic lighting. Personnel Jour., 1934, 12, 334-340.
5. Gillies, M. D. What kin are sight and light. McCall's, November, 1934, 46-47.
6. Instructions for using the foot-candle meter. General Electric Company, Cleveland (no date, but purchased in 1927), pp. 17.
7. Luckiesh, M., Taylor, A. H., and Sinden, R. H. Data pertaining to visual discrimination and desired illumination intensities. J. Franklin Institute, 1921, 192, 757-772.
8. Luckiesh, M., and Taylor, A. H. Illumination intensities chosen for reading. Trans. I. E. S., 1922, 17, 269-272.
9. Luckiesh, M., and Moss, F. K. A correlation between illumination intensity and nervous muscular tension resulting from visual effort. J. Exper. Psychol., 1933, 16, 540-555.

10. Luckiesh, M. Workers are human seeing-machines. Factory Management and Maintenance, March, 1934, 93-96.
11. Luckiesh, M. The eyes should have it (An interview by C. Brooks). Good Housekeeping, November, 1934, 88-89, 201-202.
12. Luckiesh, M., and Moss, F. K. The new science of lighting. Lighting Research Laboratory, General Electric Company, Cleveland, 1934, pp. 36.
13. Lythgoe, R. J. The measurement of visual acuity. Medical Research Council, Special Report Series, No. 173, His Majesty's Stationery Office, London, 1932, pp. 85.
14. Tinker, M. A. Illumination and the hygiene of reading. J. Educ. Psychol., 1934 25, 699-680.

CONSIDERATIONS REGARDING THE ANALYSIS AND INTERPRETATION OF DATA ON OCULAR CONVERGENCE AND ACCOMMODATION*

Charles Sheard, Ph.D., Sc.D.
Division of Physics and Biophysical Research
The Mayo Foundation and The Mayo Clinic
Rochester, Minn.

PART IV

APPLICATIONS TO THE PROBLEMS OF OCULAR REFRACTION

The Great Ocular Problem: The Efficient Coördination of Accommodation and Convergence.—This caption implies that we are concerned in this essay with applications of the methods of test and of the fundamental principles relative to accommodative and convergence liabilities and reserves, which have been disclosed in the preceding portions (1, 2) of this dissertation, to the important problem of the proper coördination of the visual functions in the act of comfortable, distinct and binocular single vision. When should prisms be prescribed and when not? When are prismatic or orthoptic exercises in general likely to be of avail? When should maximal or minimal values of convex or concave lenses be prescribed? When is operative interference necessary?

As I have stated elsewhere (3), it would take a large volume of printed pages to answer these questions and then they would not be solved.

Briefly, the following answers to these questions may be suggested. Anatomic defects may be altered by operative interference, the tonic position (disclosed by dissociation tests with fixation at distance) by prisms, lenses, or a combination of both, the accommodative convergence by lenses, and the fusional convergences by any or all of these instrumentalities.

The *deficiencies* or *excesses of tonicity*, however, may be, and quite frequently are, associated with accommodative errors and, if the disclosures made regarding tonic imbalances indicate that the values are low (except in vertical imbalances), proper refractive corrections should be given initially and a period of readjustment allowed before the incorporation of prisms in the lenses prescribed.

*Submitted for publication January 29, 1935.

Inhibition of accommodation on the one hand, or *stimulation of accommodation* on the other hand should be indulged in whenever various tests on the accommodative convergence, positive and negative relative fusional convergences, and positive and negative relative amplitudes of accommodation indicate that the function of accommodation is operative under conditions in which the *innervational* demand is disproportionate to the *dioptric demand* at the point of focus and fixation. In this group fall accommodative squints and conditions in which the squint appears only in the act of near vision. Ultimately, prisms can be of little, if any, service in the correction of such conditions, since the prescription of prisms, base out, will not aid in the restoration of proper coördination between accommodation and convergence, although such prisms may afford binocular single vision by optically annulling the need for innervation to the abducting muscles to compensate for the accommodative overconvergence. Of necessity, in such conditions, the burden in the restoration of binocular single vision falls on the negative fusional convergence, which, per se, may not be able to meet the demands made on it by reason of the excessive overconvergence. By a judicious use of prisms, base out, of such an amount as to enable the negative fusional convergence to carry the load of an overconvergence demand, optically reduced by the amount of prism (base out) inserted before the eyes, it is frequently possible to stimulate abductive action and to temporarily alleviate the squint and hasten the reëstablishment of binocular single vision.

The character and amount of the demands on the *fusional convergence* (either positive or negative) may be altered by lenses, prisms, combinations of lenses and prisms, or, in certain cases, by operative procedures. If the proper relationships between accommodation and convergence can be reëstablished, it will be found that the problem of comfortable, distinct, and binocular single vision will be solved. Attempts at training the fusional convergences, particularly in a condition of low or weak positive fusional reserve, should be made, especially in children and young adults. Simple orthoptic exercises (even the simple one of the "finger toward the nose" exercise) have reëstablished normalcy of relationships between accommodation and convergence and have afforded permanent relief from a long and "sorry" list of ocular symptoms. The difficult ocular conditions are those in which the accommodative needs, for example, demand that convex lenses be prescribed, while all tests on accommodative convergence, and in particular positive fusional reserves, show that the fusional or reflex convergence is low both in amplitude and in the reserve over and above the amount requisite for binocular single vision. In such cases, both theoretical considerations and practical experience indicate the prescription of lenses in which are incorporated an adequate lenticular assistance to the accommodation combined with small amounts of prism (1 △ to 3 △), base in, before each eye. Furthermore, in many cases much may be accomplished by stereoscopic and other training exercises.

Vertical imbalances (innervational or muscular deficiencies or excesses of the vertical recti muscles, commonly referred to as hyperphoria and hypophoria) should receive careful attention and, if they persist under repeated examinations on different occasions, should be corrected by prisms, suitable in amount and position. The prismatic values obtained by the duction tests (superduction and infraduction) are generally equal in normal pairs of eyes and do not exceed 3 △ or possibly 4 △. If the tendency to vertical dissociation exists under test at both distant and near points of fixation, and if the values of the superduction and infraduction are unequal and are reversed in value when the duction tests are made monocularly, the examiner may conclude that a genuine abnormal innervational or anatomic demand is present. In general, if this innervational imbalance is 1 △ or greater, it should be corrected. The amount of the correcting prism can be determined quite satisfactorily on the basis that the vertical fusional function cannot be called into operation in excess of one-third of its total value and, again, by the experimental determination of the amount of prism which will afford equal vertical ductions.

DICTA IN THE PRESCRIPTION OF PRISMS

There are many points of disagreement in both theory and practice regarding the use of prisms for permanent wear. A survey, on my part, which has covered a considerable period of years and a large number of articles and books relating to the problems concerned with the prescription of prisms, has indicated that those who are competent to express opinions and beliefs (based on experience and reasonably clear and satisfactory analyses and discussions of methods and data) are in agreement with the following dicta:

1. Never prescribe a prism after one examination only, but after repeated examinations, made (preferably) during different periods of the day.

2. The intrinsic and extrinsic ocular muscles (innervational resources) should be tested at the customary reading or close working distance as well as under distant fixation.

3. The tests at the reading point may disclose excesses or insufficiencies (reciprocal innervational demands for the maintenance of binocular functions) which are not disclosed under tests with distant fixation, since accommodation, accommodative convergence, and fusional convergence enter as dependent and interdependent factors.

4. There may be a considerable influence of the function of accommodation (either subnormal or excessive in value) on the function of convergence (either excessive or insufficient in value), and *vice versa.*

5. There are four main purposes for which prisms may be prescribed: (a) to compensate permanently (optically) for innervational insufficiencies or anatomic (muscular) defects which are otherwise incorrigible (many tendencies to vertical imbalance and exophoria are in this class), (b) to stimulate proper functioning of an impaired fusional

mechanism, (c) to afford temporarily such optical assistance that the innervation which goes to the extra-ocular muscles is perfectly balanced and perfectly reciprocal, and the eyes move freely either to the position of equilibrium under dissociation or to the position of parallelism (at distance) or of requisite convergence (at reading) under fusional stress, and (d) to relieve temporarily innervational and muscular tension by inducing relaxation (inhibition), and to aid in establishing normal fusional habits.

6. Prisms, base out, should be prescribed rarely, the only general exception to this statement being made in conditions which are frankly anatomic and not innervational in character. Innervational overconvergence is generally amenable to other treatment than the giving of prisms, base out.

7. A great deal may be accomplished by orthoptic and other training exercises in conditions of exophoria.

8. The prescribing of prisms for vertical tendencies to lack of equilibration is worthy of attention and consideration and, in general, such tendencies to vertical imbalance should be compensated first; tendencies to lack of lateral equilibration (esophoria and exophoria), which may be found in association, especially when of low amount, may take care of themselves and lateral orthophoria may be produced.

ANALYSES OF CASES ILLUSTRATIVE OF THE TESTS AND DATA PRESENTED IN THESE ESSAYS

In the preceding paragraphs of this essay I have outlined and briefly discussed the fundamental principles regarding the prescription of prisms. I have deferred the presentation of the analysis of data, with specific citations, to this portion of these articles, believing that the synthesis and deduction of fundamental principles, which normally should follow the analysis of data, will be the more readily accomplished and the more easily understood and appreciated if a preliminary survey has been made concerning the probable significance of certain types of findings. For the specific data in any given tabulation constitute the details, and one may easily become lost and confused in the maze of these details, which vary from case to case, unless the general principles of correlation of data (such, for example, as between accommodation and convergence), which have been derived by statistical methods, the plotting of frequency distribution curves and the like, are succinctly stated and emphatically set forth. To go into the intricacies of statistical methods, the theory of probability, coefficients of correlation, and the like, would be beyond the scope of these articles. However, in passing, it may be stated that applications of these methods to ocular data are to be found in the articles by me (4) on accommodative exophoria and by Weymouth, Brust, and Gobar (5) on ocular muscle imbalance at the reading point.

Tendencies and Expected Values.—As the philosopher René Descartes stated: "Lorsqu'il n'est pas en notre pouvoir de discerner les plus vraies opinions, nous devons suivre les plus probables" or, as trans-

lated, "When it is not in our power to determine what is true, we ought to act according to what is most probable." The letters on the charts for visual acuity (originally devised and designed by Snellen) are based on the most probable value. The size of the letters which should be read at 20 feet (V = 20/20) is not based on absolute standards but rather on the fact that the bulk of those who have normal retinal functions, clearness of ocular media, no demonstrable refractive errors, and so forth, should be able to read the specified line of letters. Hence, the reading of the letters in the line designated as V = 20/20 is the *expected* event when so-called normal acuity is present. Departure from the expected value indicates the possibility of pathologic conditions, lack of mental appreciation and interpretative ability, and so forth, on the one hand, while on the other, if the values are greater than the expectancy, there is indicated the possibility of greater retinal resolving power, academic or trained vision, and so forth. However, it is to be emphasized that departures from the normal range of expected values is not to be considered, per se, as proof of dysfunction or abnormalcy, but may be considered in the light of a finger of suspicion pointing to the necessity of further investigations and the use of check methods, together with a comparison of other data of a differential character.

With these introductory remarks and words of caution relative to the interpretation of data, I am listing again the tests tabulated in Part I of this series of essays, and citing, with brief comments, the range of values which may be expected in the various tests on eyes which are normal in visual acuity, possess adequate amplitudes of accommodation and convergence, and enjoy distinct and comfortable binocular single vision.

TABLE I

TABULATION OF NORMAL OR EXPECTED VALUES

1. History: Negative
2. Ophthalmoscopic and external ocular examinations: Negative
3. Ophthalmometric findings: Negative or 0.5 D. with the rule

DISTANCE REACTIONS

4. Phorias, (a) with correcting lenses: 1 to 2 △ exophoria
   (b) without correcting lenses: orthophoria
5. Static retinoscopy: (a) Monocular + 0.25 D. S.
   (b) Binocular + 0.25 to + 0.50 D. S.
6. Dynamic skiametry (Sheard method): (a) At 1 meter + 0.25 to + 0.50 D. S.
   (b) At 33 cm. + 0.50 to + 1 D. S.
7. Subjective findings: (a) Monocular, Nil
   (b) Binocular + 0.25 to + 0.50 D. S.
8. Lateral phoria with distance corrections: ½ to 1 △ exophoria
9. Vertical phoria: Not over ½ △
   Vertical ductions: Superduction and infraduction about equal and 2 to 4 △ in value

10. Adduction (positive fusional reserve)
    (a) Blur: 8 to 12 △
    (b) Diplopia: 16 to 20 △
    (c) Recovery: 10 to 12 △
11. Abduction (negative fusional reserve)
    (a) Blur: 4 to 6 △
    (b) Diplopia: 6 to 8 △
    (c) Recovery: 5 to 6 △

NEAR REACTIONS (FIXATION, 33 CM.)

12. Phorias at reading distance
    Lateral (a) without correcting lenses: ———
    (b) with correcting lenses: 5 to 7 △ exophoria
    Vertical: Less than ½ △
13. Cross cylinder findings (monocular): + 0.50 to + 1.00 D. S.
14. Adduction (positive fusional reserve)
    (a) Blur: 12 to 16 △
    (b) Diplopia: 18 to 22 △
    (c) Recovery: 10 to 14 △
15. Abduction (negative fusional reserve)
    (a) Blur: 10 to 12 △
    (b) Diplopia: 14 to 18 △
    (c) Recovery: 12 to 16 △
16. Vertical phoria: Less than 1 △
    Ductions: Equal in value (approximately) and 2 to 4 △
17. Amplitudes of accommodation (dependent on age)
    Subjective methods (a) Monocular: 8 D.
    (b) Binocular: 8.5 to 9 D.
    (Illustrative example for age 25 years)
18. Amplitudes of accommodation (dependent on age)
    Objective methods (a) Monocular: 7 to 7.5 D.
    (b) Binocular: 7.5 to 8 D.
    (Illustrative example for age 25 years)
19. Positive relative accommodation (minus lenses): 2.50 to 3 D
20. Negative relative accommodation (plus lenses): 2 to 2.5 D.

These data are not to be interpreted as indicating that the findings, obtained in an examination of a pair of eyes, must be the exact amounts specified in order to be classified as normal findings, but are to be considered as indicating the range or order of the expected values of findings as determined by the examination of a large group of persons who possess distinct and comfortable binocular vision at both distant and near points of fixation. These data also indicate the proportionate ratios that are found in cases exhibiting comfort and satisfactory ocular balances.

CONDITIONS OF ACCOMMODATIVE INSUFFICIENCY (OR FATIGUE), AND OF CONVERGENCE (ADDUCTIVE) INSUFFICIENCY

In order to further delineate the details concerned in the analysis and interpretation of data regarding ocular accommodation and convergence and to correlate these data in the determination of the procedures which may be followed in the subsequent management of certain conditions, I am presenting tabulations of data in cases of accommodative insufficiency and convergence insufficiency.

TABLE II

TABULATION OF DATA IN CONDITIONS OF: (1) NORMALCY, (II) ACCOMMODATIVE INSUFFICIENCY AND (III) CONVERGENCE INSUFFICIENCY

Test No.	I	II	III
1	Negative	Discomfort	Discomfort
2	Negative	Hyperesthesia and hyperemia	Hyperesthesia and hyperemia
3	Negligible	Negligible	Negligible
		DISTANCE REACTIONS	
4	1 to 2 △ exo	1△ eso	2 to 4 △ exo
5	+ 0.25 O. U.	nil	+ 0.50 O. U.
6	+ 0.50 to + 0.75 O. U.	+ 1.25 to + 1.75 D. S.	+ 1.00 O. U.
7	O. U. + 0.25	nil	+ 0.50 O. U.
8	1 △ exo	2 △ eso	4 △ exo
9	Negligible	Negligible	Negligible
10	(a) 9 △	6 △	14
	(b) 14 △	18 △	14
	(c) 10 △	12 △	10
11	(a) 6 △	——	——
	(b) 7 △	6 △	10
	(c) 4 △	4 △	8
		NEAR REACTIONS	
12	6 △ exo	Orthophoria to 2 △ exo	14 △ exo (acc. conv. = 6 △)
13	+ 0.75 D. S.	+ 1.50 D. S.	+ 0.50 D. S.
14	(a) 14 △	——	6 △
	(b) 20 △	21 △	12 △
	(c) 12 △	14 △	2△
15	(a) 11 △	6 △	——
	(b) 16 △	16 △	17 △
	(c) 14 △	12 △	14 △

16	Negligible	——	——
17	Normal for age	Low normal for age	(a) 7 D. (b) 6 D.
18	Normal for age	Low normal for age	(a) 6 D. (b) 5.5 D.
19	2.5 to 3.5 D. S. (minus lenses)	0.75 to 1.25 D. S.	3 D. S.
20	2 to 2.5 D. S. (plus lenses)	2.50 to 3 D. S.	1 D. S.

Remarks. An *analysis* of the data in Case II, in comparison with the expected values in normal conditions as tabulated under Case I, indicates: (1) Overconvergence at both distant and near points of fixation, (2) dynamic skiametric findings from 0.5 to 0.75 D. greater than the expected value (except in presbyopia), (3) relatively high adduction (positive fusional reserves) and low abductions (negative fusional reserves), (4) low positive relative amplitude of accommodation and (5) high negative relative amplitude of accommodation. The condition is fundamentally one of *accommodative insufficiency* (or fatigue). The subject of these tests should be given O. U. + 0.75 to + 1.00 D. S. for reading purposes and other close work. *Subsequent procedure* may consist in (1) exercises for the stimulation of accommodation with minus (concave) lenses and prisms, base in, (2) prism, base in, exercises only, and (3) the possibility of the incorporation of small amounts of prism, base in.

An *analysis* of the data in Case III indicates a condition of *convergence insufficiency* based on the following differential points: (1) A relatively large amount of exophoria under distant fixation, (2) dynamic skiametric findings, allowance being made for the normal lag of accommodation of 0.5 to 0.75 D., are approximately the same as the static retinoscopic findings, (3) relatively low abduction and high abduction under distant fixation, (4) a high accommodative exophoria at the reading distance, (5) low positive and high negative fusional convergences, (6) an accommodative exophoria equal in amount (approximately) to the value of the positive fusional reserve determined under test to the point of diplopia, (7) normal positive relative amplitude of accommodation and (8) very low negative relative amplitude of accommodation. The subject should be given for constant use O. U. + 0.50 D. S. $\supset$ 2 $\triangle$, base in. *Subsequent procedure* should consist of: (1) Convergence exercises, orthoptic and stereoscopic training and periodic exercising under prisms, base out and (2) training and exercises to induce an acceptance of plus lens power for both distant and near vision and to build the convergence to the point where it will be correlated properly with the function of accommodation when the proper refractive corrections are given.

In conclusion, complete and accurate data should be obtained and preserved in suitable records in every case examined. The keynote to the

efficient and proper examination of the eyes is expressed by the words *method* and *routine*. With a complete history of the case and a set of data carefully obtained, tabulated and checked, "the refractionist is master of his practices and will inevitably, if of the truly scientific trend of mind, discover facts away from the beaten paths. It is probable that in this way only may we hope to find the average busy practitioner making his contributions to ocular science." (6)

BIBLIOGRAPHY

1. Sheard, Charles: Considerations regarding the analysis and interpretation of data on ocular convergence. Amer. Jour. Optometry, 11, 412-422, 1934.

2. Sheard, Charles: Considerations regarding the analysis and interpretation of data on ocular accommodation. Amer. Jour. Optometry, 11, 448-461, 1934.

3. Sheard, Charles: Dynamic ocular tests (pages 79-80). Columbus, Ohio, Laurance Press, 1917. 143 pages.

4. Sheard, Charles: On accommodative exophoria, or the convergence associated with the act of accommodation. Amer. Jour. Physiol. Optics, 1:234-249, 1920.

5. Weymouth, F. W., Brust, P. R., and Gobar, F. H.: Ocular muscle balance at the reading distance and other related factors. Amer. Jour. Physiol. Optics, 6:184-205, 1925.

6. Sheard, Charles: Dynamic skiametry and other methods of testing the accommodation and convergence of the eyes. Chicago, Cleveland Press, 1920, 108 pages.

GENERAL REFERENCES

1. Atkinson, T. G.: Ocular muscles and fusion. Chicago, The Professional Press, 1933, 192 pages.

2. Atkinson, T. G., and Woll, F. A.: Dynamic skiametry, its theory and practice. Chicago, The Professional Press, 1928, 192 pages.

3. Davis, A. E.: Refraction and accommodation of the eye. Am. Encyclopedia of Ophth., 14:10,921-11,177, 1919.

4. Dobson, Margaret: Dynamic retinoscopy. England, Oxford University Press, 1931, 56 pages.

5. Dobson, Margaret: Binocular vision and the modern treatment of squint. England, Oxford University Press, 1933, 107 pages.

6. Duane, Alexander: Studies in monocular and binocular accommodation. Am. Jour. Ophth., 5:865-877 (Nov.), 1922.
Binocular accommodation. Arch. Ophth., 51:396-397, 1922.

7. Jaques, Louis, and Crow, George: Applied refraction, with special reference to the blur-out point technique. Los Angeles. H. R. Day Publishing Co., 1934, 123 pages.

8. Koch, C. C.: A routine refraction. Bulletin Educational Congress of American Optometric Association, 1928, 134 pages.

9. Lesser, S. K.: Fundamentals of procedure and analysis in ocular examinations, 3rd edition, 1934, 111 pages. Published by the author, Fort Worth, Texas.

10. Needles, W. B.: Ocular muscles. Dept. of Education, Amer. Opt. Assn., 1919, 34 pages.

11. Nott, I. S.: Accommodative convergence and fusion convergence. Southbridge, Mass., American Optical Co., 1928, 34 pages.

12. Pascal, J. I.: Modern retinoscopy. London, Hatton Press, 1930, 279 pages.

13. Peckham, R. M.: The modern treatment of binocular imbalances. New York, Shur-On Standard Optical Co., 1928, 184 pages.

14. Peckham, R. M.: Squints and heterophorias. Rochester, New York. Published by the author, 1931, 368 pages.

15. Peter, L. C.: The extra-ocular muscles. Philadelphia, Lea and Febiger, 1927, 294 pages.

16. Phoroptor and its use in ocular refraction. American Optical Co., 1928, 213 pages.

17. Robinson, S. H.: Oculo-prism treatment. Chicago, Professional Press, 1924, 188 pages.

18. Sheard, Charles: Dynamic ocular tests. Columbus Laurance Press, 1917, 143 pages.

19. Sheard, Charles: Dynamic skiametry and methods of testing accommodation and convergence. Chicago, Cleveland Press, 1920, 108 pages.

20. Sheard, Charles: Ocular accommodation. Department of Education, American Optical Assn., 1920, 77 pages.

21. Sheard, Charles: Zones of ocular comfort. Proceedings, American Academy of Optometry, 3:113-129. 1928.

22. Skeffington, A. M.: Ocular diagnosis. St. Louis, The Graduate Clinic Foundation.

23. Swann, L. A.: The ocular muscles. London, Hatton Press, 1932, 208 pages.

24. Tait, E. F.: A quantitative system of dynamic skiametry. Proceedings, American Academy of Optometry, 3, 1928, pages 131-161.

25. Walker, R. N.: A method of optometric quantitative analysis by certain interpretations of the findings upon a routine examination. Jour. Optometry, 11:1-27, 1934.

A STUDY OF FACTORS ENTERING INTO THE DETERMINATION OF HANDEDNESS*

Lewis H. Kraskin, O. D., F. A. A. O.
Washington, D. C.

Contents.

I. Purpose of the investigation.
II. Brief historical sketch of work done on the problem.
III. Investigation of some of the more important handedness factor theories: experimental procedure useful in such investigations and statement of statistical results.
A. Infant group.
a. Prenatal factors:
1. Dominant position of the foetus and the birth presentation position.
2. Basal metabolism of the mother.
3. Birth weight at the time of delivery.
4. Heredity factor (left-handedness in the blood line).
b. Postnatal factor:
1. Time of first tooth.
B. Kindergarten group.
a. Factors studied:
1. Degree of handedness.
2. Intelligence.
C. Sixth grade group.
a. Factors studied:
1. Degree of handedness.
2. Intelligence.
3. Heredity factor as reported in the blood line.
D. College group.
a. Factors studied:
1. Degree of handedness.
2. Intelligence.
3. Heredity as reported in the blood line.
4. Strength of grip.
5. Effect of training in a right-handed world as shown by the marking test.

*Submitted for publication July 15th, 1934.

IV. Interpretation of statistical data.
V. Conclusions.

Part I

A Study of Factors Entering Into the Determination of Handedness.

For some years there has been considerable speculation among refractionists upon the correlation between handedness and ocular dominancy. Usually there has been a real lack of appreciation of the difficulties in obtaining reliable information in handedness phenomena. It is apparent that if we wish to correlate ocular dominancy and handedness, we must first know something about handedness. The purpose of this investigation was to determine the extent of preferential dextrality, to investigate carefully some important theories of handedness and to impartially and objectively gather facts regarding handedness which could be analyzed statistically and interpreted in the light of that analysis. The intent of the study was that of a fact-finding investigation.

Extensive reading of various handedness reports brought to light the fact that the majority of studies had been made on selected groups with the result that, in the minds of educators and perhaps also the general public, the incidence of left-handedness was beginning to be coupled with speech disturbances and congenital disorders of the nervous system. The basic hypothesis of these studies seemed to be that simultaneous appearance justified the conclusion of relatedness. Such findings inspired a desire to make a fact-finding study on the incidence and degree of handedness in four representative cross-sections of the normal group, that is, infants, kindergarten children, sixth-grade children and adult college students. The results of such a study, it was thought, should indicate the effect of living in a right-handed world on the dexterity of an individual, that is, if handedness were greatly influenced by environment, the infant group should be found to be almost wholly ambidextrous and the adult group almost wholly right-handed. On the other hand, if native handedness were determined by heredity, the infant group, along with each of the other groups, should show about the same degree of right-handedness.

Before comparisons could be made it was necessary to devise a test for handedness, and this test must be one that could be used on all or nearly all groups. For this purpose the tapping test was decided to be most useful.

The actual experimental set-up for the tapping test is a very simple one, consisting of four dry cell batteries, a telegraphic key, an electric counter and a stop-watch. Each subject was allowed to tap exactly sixty seconds with each hand. Care was taken to make sure that the subject understood what was expected of him before the actual tapping began. In order that the subject should not know that his handedness was being tested, and, hence, definitely try to prove himself as having one or another form of handedness, he was told that the

test was one of reaction time. He was inspired to tap with a maximum effort in each hand in order that he might prove himself to have a high reaction time.

The results of this maximum tapping record for each hand were used to define what might be termed a handedness ratio. This was defined to be the ratio of the right hand count to the left hand count. Perhaps one of the greatest advantages of such a ratio is that it describes always the relationship between the two hands; not the speed of reaction time, but the simple degree of handedness for each hand.

Using this tapping test for handedness it was found for the kindergarten, sixth-grade and college groups that human beings are not simply right-handed or left-handed; they are a given number of degrees right-handed and a given number of degrees left-handed as determined by the tapping test handedness ratio. Thus, handedness like height of individuals and other characteristics can be represented by a continuous function within limits.

The functions describing the distribution of handedness for the three groups just mentioned were very similar. The mean of the distributions for the kindergarten, sixth grade and college groups were found to be, respectively, $1.110 \pm .002$, $1.12 \pm .006$ and $1.091 \pm .0047$. The standard deviations for the three groups were found to be, respectively, $.127 \pm .004$, $.1530 \pm .0045$ and $.138 \pm .0033$, whereas the modes were, respectively, 1.00, 1.15 and 1.05. The distribution functions resembled the normal curve of error.

Only a moderate amount of statistical analysis was necessary to indicate that the chances were strongly in favor of the assumption that the three distributions differed only by amounts that might be expected by the theory of sampling. In other words, these studies indicated that the distribution of degrees of handedness is the same for the kindergarten, sixth grade and college groups.

For the infant group four prenatal factors which might be related to handedness were investigated, the first of which was the dominant position of the foetus before birth and the heredity of the child. These factors were investigated to determine whether they were related to handedness or not.

Access was had to the birth records of Dr. H. W. Lawson, former professor of obstetrics in George Washington University, and of Dr. Howard Kane, professor of obstetrics in George Washington University. At the request of Dr. F. A. Moss both of these men had kept detailed records of the position of the foetus during the last part of pregnancy. A total of 486 cases were studied in an endeavor to ascertain the relation, if any, of the presentation position of the foetus to dextrality.

The manner of testing for handedness in this infant group was necessarily different from the tapping test. In most instances it was necessary to depend upon the telephone report of the mother regarding the handedness of the child, but a sufficiently large group were actually tested by a method which was quite objective in all its phases except one

to afford a standard of comparison for the subjective judgments given by the mothers. The subjective element in this test was introduced by having as many testers as there were children tested, in other words, each mother tested her own child. The mothers were given the following instructions on post cards:

1. On each of four days offer your child ten times each day some one object he desires.
2. Hold the desired object directly in front of your child so that no preference can be given either hand.
3. Record on the accompanying card the number of times your child reached with the right hand and the number of times with the left.

It was found that 82.2 per cent of the 138 cases for which cards were available were right-handed babies, and that this number agreed with the percentage of right-handedness in the three groups previously mentioned. For the entire group of 486 cases, represented by the 138 cases tested and 248 cases for which mothers reported subjectively, the percentage of right-handed babies was 81.6.

The right occipito-anterior and the left occipito-anterior presentation positions included 85.6 per cent of all the babies tested. The right occipito-posterior presentation position accounted for an additional 7.4 per cent of the cases. Five other types of presentation position accounted for the remaining 7.0 per cent of the cases. For the first three presentation positions named and for the other five, the percentages of right-handed babies were, respectively, 80.7, 82.1, 75.0, 80.0, 83.1, 85.7, 100.00, 100.00. If one takes into account the sizes of the samples, it follows that the chances are in favor of the assumption that the percentage of right-handed babies to be expected is constant for the eight presentation positions and is approximately 81.6. In other words, although the percentage of babies that have the presentation in which the left arm is in a fixed position and the right arm free for the period of three to six weeks before birth, during which the foetus is relatively fixed, corresponds roughly with the percentage of right-handedness reported in adult life (by a marking test or similar test of acquired ability), this is purely an accident. No relatedness whatever is indicated.

A study of the basal metabolism of the mother and its relation to right- and left-handedness, if any, was made to investigate the hypothesis that if the prenatal environment was a determinant in preferential handedness, the child of a mother with a tendency toward hyperthyroidism might show a tendency toward ambidexterity, whereas the child of a mother with a tendency toward hypothyroidism might be inclined to be either definitely right-handed or definitely left-handed. The theory back of this hypothesis was that the child of the hyperthyroid mother might be inclined to move about a great deal, and

thus to move its arms both more vigorously and more often than the child of the hypothyroid mother.

For the 156 cases for which basal metabolism of mothers were available, it was found that the average basal metabolism of the mothers of ambidextrous children, 6 cases, was —7.3; of mothers of right-handed children, 125 cases, was —3.7. From these results it would seem that the basal metabolism of the mother and the handedness of her child are not related.

Since it is known that a large child has a fixed position longer than a small one, the third prenatal factor to be investigated was birth weight. There were found to be 23 left-handed cases in a total group of 145, or 15.8 per cent. Seven of these 23 had birth weights below the average of 3,866 grams, or that is, 30.4 per cent. Seventy of the 122 right-handed babies had birth weights below the average, or that is 57.3 per cent. There may be some relationship between low birth weight and left-handedness, but it would seem that the seven cases below the average birth weight constitute too small a sample from which to draw conclusions regarding the 26.9 per cent difference between the percentage of left-handed children below the average birth weight and the percentage of right-handed children below the average birth weight.

The existence of left-handedness in the blood line was checked in 330 cases. Left heredity (mixed) was reported by 136, and right heredity by 194. It was found that 50, or 36.8 per cent, of the 136 cases were left-handed as contrasted with 16, or 8.3 per cent, of the 194. It would seem, therefore, that there may be an hereditary element involved here.

It was not possible to check the hereditary element for the kindergarten group. This element was, however, checked for the sixth-grade and college groups, and results substantially agreeing with those reported for the infant group found. It should be pointed out, however, that the percentages of right-handed heredity reported for the sixth-grade and college groups were respectively, 75.8 per cent and 74.1 per cent as compared with 58.9 per cent reported by the mothers of the infants in the infant group. This difference is probably due to the fact that the sixth-grade and college subjects reported for themselves and in most instances their familial experience included only their parents, whereas in the infant group the mother reported for the child and hence another generation was included in their familial experience.

Finally, degree of handedness was correlated with intelligence for the sixth-grade, college and kindergarten groups. For the last two groups, Pearsonian correlation coefficients of absolute value less than .15 were obtained, so that no relationship was indicated. In the sixth-grade a correlation of .6103 $\pm$ .0248 was obtained. An analysis of the data shows, however, that the greatest part of this coefficient is contributed by the tenth decile or extremely right-handed group for which the average intelligence quotient happened to be 123, Simon-

Binet scale. In view of the results obtained for the other groups, it would seem that the apparent relationship, although that indicated is not a strong one, is due to sampling.

CONCLUSIONS

It would seem that there are five definite conclusions that can be made from the results of the foregoing investigation:

1. Handedness is a trait that is manifested in varying degrees in different individuals, and the age of the subjects does not affect the degree of its manifestation. When we make a curve showing the distribution for handedness we find that the curve is slightly skewed to the left. By this is meant that there is a very slight tendency for people of any age group to be right-handed.

2. Handedness and intelligence are probably unrelated. Therefore, to the extent that intelligence and general inferiority, speech disturbances, and congenital disorders of the nervous system are related, these undesirable qualities probably are not related to handedness.

3. Some of the above data would tend to support the theory that handedness is an inherited quality, for, first, among the four samples—the infant, the kindergarten, the sixth-grade and the college groups, the statistics of the mean, the mode and the standard deviation do not vary more than might be expected by the theory of sampling, and, second, there are significant differences in the percentages of subjects both right- and left-handed who have a right- or left-handed heredity. No matter what statistical average we pursue we find that the difference between the infant and the kindergarten, sixth-grade, and college groups are negligible.

4. Handedness is not affected by the prenatal environment as it is determined by the dominant position of the foetus, or the presentation position of the child, or by the basal metabolism of the mother, or by the birth weight of the child.

5. About 81 per cent of people show greater native ability with their right hand than with their left hand as indicated by the tapping test, whereas approximately 96 per cent learn to use their right hand preferentially as indicated by the number marking test. In other words, seventy-five per cent of those who have greater native ability in their left hand as indicated by reaction time (tapping test) develop preferential use of the right hand presumably due to the effect of living in a right-handed world.

6. In the absence of a definite testing procedure conducted along the same lines as those used in this investigation, the actual handedness could not be determined positively. The mere fact that an individual uses the right or the left hand for writing, etc., is not sufficient evidence of handedness such as would be required if an attempt were made to correlate apparent ocular dominancy and true handedness.

Part II

Historical Sketch.

There seems to be no phase of the record of man which does not bear a record of his dexterity. Indeed, it would seem that language, social and religious rites and man's handicrafts throughout the whole period of his existence have been profoundly affected by his preference for the right hand.

D. J. Cunningham[1] in the Huxley Memorial Lecture of 1902 makes the following statement regarding right-handedness:

> "It is easy to prove that the characteristic is one of great antiquity. Of this there is the clearest evidence not only in historical records and pictorial representation but also in ancient mythology and in the structure of almost all languages. The Amazon had the right breast destroyed in order that she might hurl the javelin and shoot the arrow with greater dexterity; Hercules holds his clubs and Neptune his trident in his right hand; whilst with the same hand King Rameses adjusts his bow. But the remoteness of the origin of dexterity is also attested by the fact that in almost all languages—both living and dead—in those employed by the so-called civilized races as well as in those spoken by the more barbarous peoples, there are words and phrases which indicate the difference between the two sides and often words which express certain general qualities which are supposed to characterize these sides. In our own language we have 'adroit,' 'righteous,' and so on; in the French there is 'gauche,' with its equivalent in English 'gawkie' and in Scotch 'gowk'."

D. G. Brinton[2] has studied the manner in which arrow and spear blades have been trimmed and considers that a greater facility in the dressing of the right side is apparent in the proportion of 3 to 1. He goes on to say:

> "the hand preferred was no doubt the right hand, but the notably large pro portion of 33 per cent for probably left-handed work indicates either that there were more left-handed persons or as I prefer to believe there were more who were ambidextrous. This may have been due to the fact that the methods of flint chipping favored the development of both hands, but it is likely that it indicates a general physiological tendency."

D. J. Cunningham states that it is a matter of common knowledge that the more extensive use to which the right upper limb is put reacts upon its development and causes it to assume more massive proportions than its fellow of the left side. With this in view he searched the literature in order to find whether any observations had been made on the remains of prehistoric man with the view of determining whether the bones of the right arm exhibit a corresponding excess of development. The results of his search in his own words are[3]:

> "So far as I am aware Dr. R. Lehmann-Nitsche is the only one who has investigated this matter. He has found that the clavicle and lung bones of the upper limb of prehistoric man of Southern Bavaria are distinctly heavier and more massive than the corresponding bones of the opposite side. This may be regarded as affording positive proof that these early individuals were right-handed."

---

[1]D. J. Cunningham, Right-Handedness and Left-Brainedness, Jour. Anthropological Institute, Vol. XXXII, p. 274.

[2]D. G. Brinton, Left-Handedness in North American Aboriginal Art, The American Anthropologist, Vol. IX, 1896, p. 175.

[3]D. J. Cunningham, loc. cit., p. 279.

D. J. Cunningham[1] quotes from a letter he had received. He says:

> "In a letter which I have received from Dr. Haddon, there is the following interesting statement: 'Rivers told me that in Murray Island out of a total of 450 there was the same proportion of left-handedness as in Europe.' Dr. W. McDougall, who likewise formed one of the Cambridge expedition to the Torres Straits, has also given me some information regarding the Murray Islanders. He states that, 'in some cases there was very little difference in strength or skill or preferential use of either hand. I took readings with a squeeze dynamometer from both hands of thirty men and boys, taking as many readings with either hand as I could obtain without indications of fatigue or loss of interest—generally six or seven, with either hand being used alternatively to obviate differences due to practice or fatigue. Of these thirty cases twenty-four made a stronger average squeeze with the right hand—the superiority of the right hand varying from three to thirty per cent, and the average superiority being eight per cent. Of the others four gave almost equal average squeezes with the two hands and only one gave stronger with his left—this about ten per cent stronger.' He further adds: 'I think the difference in manipulative dexterity between the two hands and also the preference for the use of the right hand was less marked than in ourselves; although this is no doubt due merely to the fact that they do very little work requiring any great degree of manual dexterity.' "

Buchanan[2] was one of the first investigators to point out a physiological basis for right-handedness. He contends that the right side of the body, in so far as the action of the upper right limb is concerned, possesses certain mechanical advantages over the left side, that the right lung is more bulky than the left lung in the proportion of eleven to ten, and that consequently when a deep breath is taken a more stable basis of support is given to the right upper limb. He contends that the placement of the viscera in the abdominal cavity is of even greater importance than the relatively large right lung. He points out that the solid, massive liver occupies a very large part of the right half of the cavity, whereas the left half is chiefly filled by the hollow viscera, i. e., the stomach and intestines. He contends, therefore, that the right side of the abdomen affords the upper limb a more solid and compact support. Buchanan backs his contention with an interesting observation:

> "If the use of the right hand were a mere conventional arrangement founded on utility and expediency, and inculcated by precept and practice on a docile and obedient posterity, it would have varied like every other human institution left to voluntary control. Love of change, fancied utility, the spirit of opposition and mere caprice would, in every age of the world, have rendered the use of one hand as common as the use of the other. If the barbarians, who tattoo their faces, compress their skulls, distort their feet, and otherwise mutilate and disfigure the human frame are, nevertheless, all of them, just as unanimous as civilized nations in the preference of the right hand over the left, we may rest assured that it is not a mere matter of choice on their part, which hand they ought to prefer."

---

[1]D. J. Cunningham, loc. cit., p. 279.

[2]Buchanan, Mechanical Theory of the Predominance of the Right Hand over the Left; or more generally of the limbs of the Right Side over these of the Left Side of the Body. Proc. Phil. Soc. of Glasgow, Vol. V, 1862, p. 142.

D. J. Cunningham[1] advances the following theory:

> "The motor paths which take origin in the cortex of the two cerebral hemispheres cross to opposite sides of the body as they proceed to their ultimate destinations. It thus comes about that the left cerebral hemisphere controls and regulates the muscles of the right side, and its functional superiority over the right hemisphere is indicated by the subservient position which the left hand holds with reference to the right, and the manner in which all manual acts which require precision and skill, all the movements which specially require the higher guidance of the brain, are performed by the right hand. . . . left-brainedness and right-handedness constitute the normal condition; whilst right-brainedness and left-handedness are to be regarded as an exceptional occurrence.
>
> The functional preeminence of the left brain is not a haphazard acquisition which has been picked up during the life of the individual. It is not the result, but through evolution, it has become the cause of right-handedness."

In another instance Cunningham[2] sums his view thus:

> "Right-handedness is an inherited quality in the same sense that the potential power of articulate speech in man and of song in the bird are inherited possessions. Every normal child is provided with the complicated brain and nerve mechanism which is required for the successful acquisition of speech, and, yet, unless these nerve centers and nerve paths are brought into play and practiced by the education which every generation gives to the succeeding generation, no outward manifestation of this potential power results."

It is unnecessary to further discuss the various theories at this time; a summation of them will suffice. They are: habit, ocular dominance, hereditary-transmission, nursing and early education, primitive warfare, origin of the sub-clavian arteries, inequality of blood supply to the brain, superior-development of one cerebral hemisphere, the left-sided location of the heart, and a greater supply of nerve force to the muscles because of an earlier and greater development of the brain upon one side.

Some of the more recent contributions have brought out some interesting results. For instance A. L. Gesell after years of experimentation with very young infants makes the following statement[3]:

> "Under extremely diverse, ambiguous and intermittent social suggestions we have found that the great majority of infants of the present day show a progressive tendency toward right-handedness which becomes well established in the second half of the first year. The fact that under similar conditions a significant minority of infants show equally well defined left-handedness is itself suggestive of more deep seated if not hereditary factors."

H. D. Chamberlain[4] also has done an interesting piece of work, the results of which may have significance. His study included:

---

[1]D. J. Cunningham, Right-Handedness and Left-Brainedness. The Journal of the Anthropological Institute, Vol. XXXII, p. 287.

[2]Loc. Cit., p. 281.

[3]A. Gesell, Infancy and Human Growth, New York MacMillan, 1928.

[4]H. D. Chamberlain, Jr., Inheritance of Left-Handedness. Heredity, Vol. 19, pp. 557-559.

2,177 students — 4.31%—of whom were left-handed.
4,354 parents — 4.13%—of the fathers were left-handed.
4,354 parents — 2.94%—of the mothers were left-handed.
2,682 sisters — 3.76%—of whose sisters were left-handed.
2,855 brothers — 4.96%—of whose brothers were left-handed.
12,068 total — 4.34%—of whom were left-handed.
4,859 total — 3.39%—of the female group who were left-handed.
7,209 total — 4.96%—of the male group who were left-handed.

CHAMBERLAIN'S DATA. TABLE 1.
HEREDITY AND HANDEDNESS

	TOTAL	Left-Handed Boys	Per Cent	Left-Handed Girls	Per Cent	Total Left-Handed	Per Cent
Families Father Left-Handed	82	21	12.2	5	5.2	26	9.7
Families Mother Left-Handed	55	18	14.01	9	13.02	27	13.77
Families Both Parents Left-Handed	33	26	39.6	20	54	46	46
Families Both Parents Right-Handed	2031	223	5.1	84	3.1	307	3.9
Total Families Observed	2177	267	5.3	101	3.8	368	4.83

Chamberlain's table containing other data obtained from families and children given above will be helpful here (see Table 1). Chamberlain's conclusions equal his results in interest. They are:

> "Hence from families in which one or both of the parents are left-handed we get a percentage of 17.34 of the children left-handed, while in families in

which neither of the parents are left-handed, 3.1 per cent of the children are left-handed.

If left-handedness is not inherited we would not find over 5 per cent of the children left-handed in any of these families regardless of the handedness of their parents.

It is very evident that there is some sex influence manifested in the inheritance of left-handedness as shown by the larger number of left-handed boys in this population. It is also apparently transmitted differently where the father is left-handed as note the small number of left-handed girls in these families. There can be no doubt that the trait is inherited, but certainly, not as a Mendelian recessive."

J. G. Yoshicka[1] makes an interesting report on handedness in the animal world. He makes mention of Franz' observation that monkeys show preferential dextrality, and then proceeds to give an account of his own study. He found that some rats have a longer right or left forelimb and, hence, manifest decided preferential dextrality. His results can best be shown by his own table:

TABLE 2
DISTRIBUTION OF HANDEDNESS IN 100 RATS

	Right Hand	Left Hand
Equal right and left bones	35	22
Longer right bones	15	0
Longer left bones	0	23

He further noted a larger number of young rats with bones of unequal length than old rats. It will be observed that he found his right-handed rats had longer right forebones and that his left-handed rats had longer left forebones without exception, save in those cases where the right and left bones were of equal length in which cases the chances were only slightly more in favor of the rats being right-handed.

Finally, much has been written regarding the relation of handedness and speech. R. H. Ojeman[2] made a study of this relationship and gives the following summary of the data observed:

"Two of the twenty-three dextrosinstrals evidenced speech defects at the time they were tested. In these two cases the speech disturbances appeared when the child first learned to talk. Four of the twenty-three subjects were reported to have had a speech disturbance at some time previous to the investigation. In these cases no connection between the training in using the right hand for

[1]J. G. Yoshicka, Handedness in Rats, Pedagog. Sem., Vol. 38, 1930, pp. 471-474.
[2]R. H. Ojeman, Studies in Handedness, J. Ed. Psychol., Vol. 21, pp. 597-611.

writing and the speech disturbance could be established. The remaining seventeen dextrosinstrals had developed no speech defects at any time."

From these results he concluded the following:

"These data tend to show that in training a left-handed individual to write with the right hand, the handedness of the subject is not a sufficient condition to cause a speech disturbance. It appears to be the exception rather than the rule for a speech disturbance to be produced by training a left-handed individual to write with his right hand."

Sir Daniel Wilson[1] in his book on left-handedness makes the following interesting reference:

"Towards the close of a long life in which Thomas Carlyle had unceasingly plied his busy pen, the dextrous right hand, that had unflaggingly toiled for upwards of three score years in the service of his fellow-men, was suddenly paralyzed. The period of life was all too late for him to turn with any hope of success to the unaccustomed and untrained left hand; and more than one entry in his journal refers to the irreparable loss. But one curious embodiment of reflections suggested by this privation is thus recorded by him upwards of a year after experience had familiarized him with all that the loss involved: 'Curious to consider the right hand among universal mankind; probably the very oldest human institution that exists, indispensable to all human co-operation whatsoever. He that has seen three mowers, one of whom is left-handed, trying to work together, and how impossible it is, has witnessed the simplest form of impossibility, which but for the distinction of a "right hand," would have pervaded all human beings. Have often thought of all that,—never saw it so clearly as this morning while out walking, unslept and dreary enough in the windy sunshine. How old? Old! I wonder if there is any people barbarous enough not to have this distinction of hands; no human Cosmos possible to be even begun without it. Oldest Hebrews, etc., writing from right to left are as familiar with the world-old institution as we. Why that particular hand is chosen is a question not to be settled, not worth asking except as a kind of riddle; . . . .'"

It is Carlyle's riddle that we have chosen to investigate.

(To be continued in the March issue.)

DR. LEWIS H. KRASKIN,
WASHINGTON, D. C.
516-518 WASHINGTON LOAN & TRUST BLDG.,

---

[1]Sir Daniel Wilson, Left-Handedness, Nature Series, MacMillan, London, 1891.

AN OCULAR DIAGNOSIS FOR INTESTINAL AUTO-INTOXICATION*

Russell E. Simpson, O.D.; F.C.O.R.I.
Pasadena, Calif.

I want to discuss what to me is the ultimate in visual care. I mean the consideration of all phases of vision, ocular, physiological and psychological. I shall not only discuss what seems the ultimate but shall attempt before finishing to offer a partial solution to its achievement.

The ultimate in visual care will be when we as eye specialists, and I include medical as well as optometric, cease to consider vision, as only the ocular globe, a lifeless mechanical apparatus; and when we realize that we are fortunate in having been blessed with the right to practice a profession second to none in the possibilities for service to our fellow men. A profession whose possibilities we have as yet not realized, a profession which we as optometric eye specialists can develop to a practically unlimited degree in the field of diagnosis. In addition to present methods which are largely refractive, the ultimate will be the recognition that systemic poisonings must be considered in every case presented to us for care.

Our patients come to us for relief from certain symptoms. These may run the gauntlet of frontal headache, temporal, occipital, vertex ache, smarting, burning inflamed lids, dizziness, nausea, dimness of or painful vision, night blindness, difficult concentration, impaired memory and so forth.

Too long have optometrical and medical eye specialists limited the treatment of these symptoms to refractive methods alone, without having first eliminated other causes.

We have accepted headache as a symptom of refractive eye strain, prescribing for it without eliminating other possible causes by our examination. We have accepted the statement that it was normal to expect an increase in exophoria at the near point as the patient's age advanced. That macular degeneration in the aged was senile and nothing could be done for it. We have expected that our patient's visual acuity should decrease as age advances. And we have fitted adolescents with myopic corrections, when the mere fact that the condition has come about suddenly should indicate some causative factor other than our

*Presented before the Minnesota Academy of Optometry at the University of Minnesota, Minneapolis. September 18, 1934.

accepted theories of the cause of myopia. We may expect to demonstrate some disturbance of the endocrine glands in these cases.

For too long have we hoped our prescription would correct a conjunctivitis, a blepharitis, that the smarting and burning would be relieved, and if it did not, we would change the prescription a quarter sphere or a quarter cylinder. The patient, failing to gain relief, loses faith not only in us but the entire profession and tries another eye specialist. Probably continuing along the same path, hoping some day for relief. In these same cases medicine too has treated them as local conditions.

We have accepted blurring as one of the simplest of symptoms with which we have to deal, and prescribed the refractive correction without due consideration for other causes. Our patients do not differentiate between the blurring caused by refractive errors and that caused by irritation of the rods and cones or of the higher visual centers of the brain. We have no right to assume that blurring is due to refractive error alone, even though we find a fairly high degree of error. The fact that the patient complains of the blur should indicate something else as the cause, for the blur of such a case would have been present for some time. I think we should want to know, when does the blur occur, is it constant, or clearing and blurring, is the entire object looked at blurred, is there nausea with or following it, is headache an accompaniment, do flashes of light appear with, preceding, or following it.

If a spasm of accommodation is present we have assumed it was purely refractive. How about the case in which we find a spasm of accommodation, and having made the most accurate examination possible, when through we find we have practically the same prescription the patient is wearing? Patients complain of dizziness and we find a muscular disorder, possibly of the elevating muscles. We assume that as the cause. We must eliminate other possible causes before we can honestly come to such a decision.

What must command our interest is the cause back of these conditions. The eye symptoms I have enumerated may all be caused by systemic disease.

Incipient cataracts should call for the most thorough physical examination. Many of these cases are being arrested by correcting a chronic constipation, a colitis, a nephritis, and so forth. Medical laboratories can be of great service in this field. Blood analyses frequently contribute to the diagnosis. How much better off is the patient if the condition is arrested while vision is still present in a usable degree, even though it is necessary to prescribe possibly an add 4.00 sphere for reading. Reduced vision in an eye still functioning normally is far better than an eye that has gone on to a cataract operation. Particularly is this so if the cause of the cataract had not been eliminated, so that the fundus was also affected.

Many cataracts removed by operation could have been prevented had present day findings been employed in their early treatment. We in turn have viewed cataract cases as refractive or operative. We should refer the case to a practitioner for a thorough physical examination, as many

cataracts are an effect of disturbed metabolism, of some interference with the normal nourishment of the crystalline lens. Unfortunately cataract is seldom considered as pathologic, as due to some systemic poisoning and most eye specialists, both medical and optometric, consider pathology of the general system only when some fundus change is evident with the ophthalmoscope.

It is not difficult to diagnose disease of the fundus with the ophthalmoscope. Among the instruments available, the stationery Geneva instrument is probably the best, although it has been discontinued by its makers. While the magnification is not so great, this instrument has a larger field, making possible the comparing of larger areas under examination. It also makes possible the demonstration to a third person of the fundus. From a psychological viewpoint, in demonstrating our ability to view the fundus without the aid of belladonna, this is invaluable. If more magnification of a specific area is desired a hand instrument can always be used.

Recently we have been advised that if the refractive error does not seem sufficient to cause the symptoms the color fields should be examined. A check to determine the presence of systemic poisoning in every case would seem advisable regardless of the refractive error found. And not only should we eliminate exogenous poisoning or poisons taken into the system, but of probably more importance is the determination of endogenous poisonings in their incipient stages.

We have been taught to diagnose chorioditis, retinitis, albuminuria, nephritis, diabetes and the other changes in the fundus seen with the ophthalmoscope. To determine disturbances prior to the time these diseases manifest themselves in the fundus is of far greater service. Once the products of disturbed metabolism are apparent in the tissues of the eye destruction has probably commenced and the permanent relief for the patient from that disease is problematic. Although, we do know that fundus changes frequently are the earliest diagnostic points found. Certainly unless a definite diagnosis is made and adequate treatment instituted the functioning of that eye from then on is impaired.

Kidney disorders, liver and gall bladder disturbances, circulatory disorders, anemia, arterio-sclerosis, constipation, syphilis, etc., may all manifest themselves in the eye in the form of chorioditis, retinitis, cataract, iritis, inflamed, thickened crusty lids. Long before the products of these systemic diseases appear in the fundus, or the disease becomes chronic, we find a disturbed functioning of the nervous and muscular visual system; we find inflamed heavy tired lids, dull headaches, blurred vision, floating spots, difficult concentration, photophobia, spasm of accommodation, disturbed ratios of supply and demand, innervations inadequate and reserves depleted and memory poor. The causes then of these symptoms that have too long been considered as refractive may be disturbed function of other organs of the body or systemic poisonings. Then the ultimate will be, when we determine for every patient, whether there

is some systemic poisoning affecting vision and contributing to the symptoms present.

The great American curse is intestinal auto-intoxication. It may be only constipation or it may be complicated with disease or malfunctioning of organs taking part in determining the normal nourishment of the body. I shall attempt to demonstrate to you how to determine from your examination of the visual apparatus whether constipation or dietary disturbance is affecting the vision. By this same method it is also possible to determine whether a condition of anemia or a liver or gall bladder disturbance exists which affects vision. We shall, however, demonstrate in particular the condition of constipation. Simple questioning of the patient will be sufficient in these cases to determine the probable correctness of your diagnosis. A large percentage of chronic inflammations of the lids can be traced to these causes, as also may a large percentage of chronic eye diseases be traced to digestive and eliminative poisons. Illustrating this is a case of unilateral almost constant frontal headache, with chronic inflamed lids, occasional stringy pus, aggravated photophobia, metamorphosia in which objects appeared to be fading away into distance. The color fields showed a decided contraction for blue; red and and green both slightly reduced in size. The innervational reserve for near 18 degrees positive and 15 degrees negative. Diagnosed as a case of chronic constipation, colonic irrigation over a period of six weeks corrected the symptoms. This case showed no fundus changes, other than engorged veins. The color fields of this case may be seen by those interested.

Another case was one in which the complaint was blurred vision and floating spots before the eyes and photophobia. The lids were typical of jaundice and anemia. Questioning determined the patient never had a bowel movement without an enema or a cathartic. This patient, referred to her physician, received treatment for constipation and anemia. Twelve years later gall stones were discovered by X-ray.

Hundreds of similar cases are on record. One symptom will be noticed as prominent in all cases enumerated, that of photophobia. Every case in which photophobia is a complaint should be suspicioned as having a background of systemic poisoning. Before tinted glasses are prescribed this cause should be determined. If systemic poisoning is present, tinted glasses which reduce vision should be prescribed until such time as the cause has been corrected.

An extreme case of this type was a woman 73 years of age. She came wearing constantly No. 5 smoked glasses and an eye shade, being able to read only the largest Jaeger type. Examination disclosed typically chronic inflamed lids, a diffuse cataractous haziness of the crystalline lens. Vision corrected was 20/100. The fundus was negative except for an arteriosclerosis. Three months later after colonic irrigations, a corrected diet, a mild daily cathartic of senna prunes, and new glasses with an add 4.00 for reading, she read No. 1 Jaeger type at ten inches and wore No. 3 Crookes lenses outdoors only. Cooperation between a general practicing

physician and the optometric eye specialist gave this patient a new lease on life.

The procedure in suspected cases of systemic poisoning should be as follows: If you suspect your patient has an abscessed tooth you should refer him to an X-ray specialist, if his report is positive refer him to an exodontist; if you suspect your patient has a kidney disorder he must be referred to a laboratory for a urinalysis, if the report demonstrates albumin, an abnormal specific gravity, etc., refer the patient to his family physician; if you can demonstrate a constipation refer him to his family physician or osteopath; if you find some abnormal condition of the body but cannot be definite, refer the patient to either an osteopathic or medical physician who has adequate laboratory facilities or to a metabolic clinic. In any case you should contact the professional man to whom you refer the case, advising him of your expectations and collaborating with him on findings. Books on laboratory medicine, nervous disorders and diseases of the eye should be available (I). The correct prescription for glasses should, of course, be prescribed AFTER a diagnosis is made, relieving the patient's symptoms as much as possible. The prestige of eye specialists will be greatly enhanced when we learn to recognize early functional and organic disturbances of the body, before the disease is recognizable in the fundus.

Their early recognition puts the practitioner in the field of prevention. Great care must be taken in selecting the physician to whom cases are referred. It has been our experience that they too often are not interested in minor ailments or in cases where the patient has not clearly recognizable symptoms. One should handle the patient so that his confidence is assured, and if negative findings are reported by the physician, that patient should be kept under observation, with the expectation of the condition becoming aggravated later on.

Illustrative of the foregoing was a case in which a liver disturbance was suspected. The physician's report was negative and yet two weeks later the patient was taken with an acute attack.

Another case seen in consultation may be cited. A boy ten years of age complained of his eyes smarting when reading. His optometric eye specialist found several degrees of exophoria over normal, recommended neuro-muscular treatments. These were instituted but failed to relieve the symptoms. A consultation was held. Examination of the lids showed a condition of jaundice. The family physician dismissed the case with the remark that, when proper glasses were fitted, the boy probably would be all right. Two glasses of orange juice and four glasses of water a day and sweets partly eliminated were recommended by a second physician after the optometric consultant had discussed the case with him.

Cases of this nature and those showing more definite symptoms of systemic poisoning must be recognized by the optometric eye specialist and referred for proper treatment.

We must prescribe glasses only when they will relieve the patient's symptoms, or with the full understanding that the glasses will give only partial relief. An examination must be made that will disclose the normal or abnormal functioning of the entire visual apparatus. We must evaluate symptoms. Certain symptoms can almost surely be classed as not refractive. We must realize the eye functions as part of the entire body, that the visual nervous system functions as part of the entire neural system, that the poisons created by the other organs of the body and digestive and eliminative tracts are carried to the eye and that no organ can function better than the nourishment furnished it.

We have a wonderful organ in the eye with which to work. Including the Oculist, we are the only profession dealing with the correction of health, that can see into the organ we examine; see the blood coursing through the veins and arteries without their having been affected by any outside interference. Count the pulse; and actually measure the innervation required by that visual apparatus, determine the amount used and determine the amount in reserve. Some of you may have read the report of the case "Metastatic Calcification" recently submitted to the American Journal of Optometry. This is one of those rare cases in which the body is turning to stone and is illustrative of how far reaching, visual diagnosis by optometric eye specialists may be. During the period this case was under observation an attempt was made to have the mechanical and electrical neuro-muscular tonicity tested. We were unable to have these tests made in southern California either by any medical man or group or at any of our universities or schools of learning. The nearest we could approach it was to have a test made, by which one practitioner could say in his opinion such and such a condition was present. This opinion to be based entirely on reactions that could not be authenticated by any other practitioner. Yet optometric eye specialists can make neuro-muscular tests on the visual apparatus in California that you in Minnesota can check as accurately as we had done.

I said I would attempt to leave with you a partial solution of the ultimate in visual care. That ultimate may be achieved, when every optometric eye specialist assures, by adequate measures, the health of every pair of eyes examined.

DR. RUSSELL E. SIMPSON,
405 PACIFIC SOUTH BLDG.,
PASADENA, CALIF.

DUOCHROME-CROSS CYLINDER CHECK TEST*

William Smith, Opt.D., D.O.S.
Roxbury, Mass.

The Duochrome test, in which Red-Green colors are used as a check test, is fast becoming part of the optometrists's routine procedure. There has always been a demand for a simple, yet accurate check test of the subjective examination and no one test employed has been found to possess the scientific accuracy which the Duochrome test possesses.

This test utilizes the chromatic abberation of the eye. It is a proven and accepted fact that the Emmetropic eye is Emmetropic for yellow, Hyperopic for red and Myopic for green. Red light focuses clearly on a myopic retina; while a hyperope will see green the clearest. The Emmetrope would see both colors or the objects on a half red and half green background equally clear. But this test applies most accurately to spherical errors, although some use it in checking compound errors also.

The Cross Cylinder test much in vogue at the present time both as check and as a diagnostic test, could be used jointly with the Duochrome for the accurate determination of compound corrections and in simple Astigmatism of any degree. The resultant combination discloses the actual refractive status of a pair of eyes and the test is carried out with utmost ease because of the simplicity with which it is done.

The Cross Cylinder creates in the eye a condition of false Astigmatism. In an Emmetropic eye or an eye properly corrected, the lines on the Cross Cylinder chart appear equally black and clear. Under or over corrected Astigmatism will show up by an inequality in the clearness of the lines. This can be adjusted before proceeding with the check test.

In checking Astigmatic errors as well as spherical and compound anomalies, the combined Duochrome and Cross Cylinder test is invaluable. One checks the chromatism of the eye; the other, by creating a false interval of Sturm, creates a mixed Astigmatism of equal amount. Any discrepancy in the prescribed correction will be noticed during this test.

In checking with the Duochrome, each eye separately is tested. It is best to blur vision slightly and when the red-green slide is introduced, to ask the patient on which side he can read the letters clearest. If the letters

*Submitted for publication September 29, 1934.

appear clearest on the red side, the Hyperope is overcorrected and the Myope undercorrected. If the letters are read easier on the green side, the Hyperope is undercorrected and the Myope is overcorrected. The Emmetrope sees the letters equally as clear on the red as on the green background

The Cross Cylinders employed are either the +0.25 D. Sph. ⊂ —0.50 D. Cyl. Ax. 180 or the +0.50 D. Sph. ⊂ —1.00 D. Cyl. Ax. 180 combination. The latter is preferred because it makes a more noticeable variation in the blackness of the lines. As in the Duochrome test, a variation in the clearness of the letters on the double chart or on the Astigmatic dial or "T" chart will be noticed, if there is an over or undercorrection of Ametropia.

Both tests are for distant use, although the Cross Cylinder is also used for near check up. Each test can be employed independently of the other. The technique described involves the use of both tests in combination. This combination is surprisingly different. It forms a highly sensitive check test and will pick up a variation of an eighth of a diopter with exactness. The difference between the combined test and the single test, either with the Duochrome or with the Cross Cylinder alone, is that with the former, spherical discrepancies are uncovered and with the latter, cylindrical, whereas with the combined test both these elements can be corrected at the same time. Of course it is claimed that the Duochrome test will determine variations in the cylindrical element of a prescription as well as in the spherical; and that the Cross Cylinder will likewise pick up under and overcorrected cylinder element, even if each test is used independently of the other. This, nevertheless, is not always so. The Duochrome is dependable for checking spherical errors primarily; the Cross Cylinder is reliable in detecting cylindrical variations at distance and spherical discrepancies at near mostly. Sectional accommodation, latency, poor illumination, uncooperation on part of the patient and many other elements make the Cross Cylinder somewhat unreliable as a check test for Astigmatism at near. But at the far point it is an invaluable check test and when combined with the Duochrome it becomes indispensable.

The technique for taking this test is very simple. At the close of the subjective examination the Duochrome screen is turned on. One eye is checked at a time. The patient is asked to report the side on which he can read the letters clearest. Whatever variation exists is corrected. Then the Cross Cylinder is inserted and the patient is asked to compare again and to report the side on which either the letters or the lines appear clearest. After each eye is thus checked, the procedure is repeated with both eyes and variation noted. Whatever variation exists is interpreted in accordance with the outline given in a preceding paragraph.

DR. WILLIAM SMITH,
260 SEAVER STREET,
ROXBURY, MASS.

AMERICAN JOURNAL OF OPTOMETRY

VOL. 12 FEBRUARY, 1935 No. 2

EDITORS

DR. CAREL C. KOCH
1501 Foshay Tower
821 Marquette Avenue
Minneapolis, Minn.

DR. JACK I. KURTZ
1501 Foshay Tower
821 Marquette Avenue
Minneapolis, Minn.

Original papers, scientific communications, clinical reports, society proceedings, books for review, and correspondence should be sent to the Editor, Dr. Carel C. Koch.

Annual Subscription, $4.00 in Advance, Canada and Foreign, $5.00.
Single Copies, 40c.

Copy of advertisements must be sent in by the tenth of the month preceding their appearance. Subscriptions, applications for single copies, communications with reference to advertising or other business should be addressed to the Business Manager, Dr. Jack I. Kurtz, 1501 Foshay Tower, Minneapolis, Minn.

Published Monthly by the
American Journal of Optometry Publishing Association.

The Journal has no objection to the reprinting by other magazines of any of its articles, provided such reprints are properly credited to the Amerian Journal of Optometry.

MASSAGE AND THE CORRECTION OF OCULAR SYMPTOMS

Mechanotherapy in the form of massage has been used by optometrists as a supplement to other orthoptic treatment therapies for a considerable period of time, in certain squint cases[1] and also to stimulate the circulation in cases of amblyopia ex anopsia[2]. Bennett also reports treating hyperopia and myopia by means of massage.[3] That this therapy has been of value in correcting these defects there can be no doubt but it is not sufficiently appreciated that massage has analgesic potency. Many an ocular pain can be relieved by skillful rubbing. Of course, in traumatic ocular involvements and infectious inflammations of the eyes, a stage exists when the affected part must not be manipulated directly, but even in these cases, long centripegal strokes applied gently to the closed lids may have remedial potency by favoring drainage from and lessening tension within the affected part.

[1] Cowan, John. Physical treatment in eye conditions. The Dioptric Bulletin. Vol. XXX, No. 6, pp. 290-294. 1928.

[2] Koch, C. C. Massage as an aid in treating amblyopia ex anopsia. Amer. Jour. of Optom. Vol. 5, No. 12, pp. 614-616. 1928.

[3] Bennett, R. W. p. 288. Ocular Physical Therapy for Optometrists. Kurtz. Published by Amer. Jour. of Optom. 1930.

This external massage is employed at times to an eye just recovering from acute inflammation, as the tissue thereby becomes more tolerant of other corrective aids. These cases, of course, are non-optometric but being ocular are of interest to us as optometrists. Massage, however, does also have a place in the correction of ocular symptoms which fall wholly within the optometric category. This is true particularly of those cases suffering from long-standing imballances of the extra-ocular muscles. These cases are frequently benefited by a type of massage which combines the kneading and the friction or circular technics. Of course these treatments must be administered to the closed lids gently or harm will be done, but in many cases immediate relief from distressing ocular symptoms can be obtained while the customary orthoptic treatments are being given. The physiological reaction to this type of ocular massage may be explained in the following manner. When the lids are gently squeezed, and especially when this squeezing is alternated with long gentle strokes there are sent onward into return circulation, fluids and other materials that have stagnated in the tissue, and the valves preventing reflux, we find the tissues thus treated becoming perfused with fresh arterial blood. One may perhaps visualize the effect of such treatment by thinking of the way in which by squeezing it, intermittently, one can greatly expedite the cleansing of a sponge immersed in water.

Such procedure is of course not recommended as a cure-all for any of the ocular abnormalities. It is used only to supplement other measures and in certain cases to more quickly relieve symptoms which without this aid might prove quite distressing. Whether massage was properly applied or not may be judged by its results. Decrease of pain usually follows its application in stubborn, painful cases of extra-ocular muscular imbalance.

C. C. K.

* * * * *

THE RÖNTGEN OR X-RAYS

It was in the autumn of 1895 that Professor W. K. Röntgen at Würzburg, Bavaria, discovered the rays which now bear his name. During the course of a series of physical researches on invisible light rays, he had enclosed a discharge tube within a screen of stout black paper. Later on, passing the discharge, he noticed that a fluorescent screen, lying on a table some distance away, shone out brightly. By interposing various obstacles Röntgen traced back the unknown or "X" rays to their source, which proved to be the region of impact of the cathode rays on the walls of the tube. The feature of the new rays, which he at once recognized, was their uncanny ability to penetrate many substances which were quite opaque to light. The degree of penetration was found to depend roughly on the density of the substance under examination. For example, body tissue is more transparent than bone, and accordingly, when exposed to X-ray, the bones stand out dark in the shadow caused on a fluorescent

screen. Röntgen saw at once the immense importance of his discovery to medicine and surgery, and communicated his results to the Physico-Medical Society of Würzburg in November, 1895.

The principle features of the rays were soon discovered by many technical laboratory workers. It was found, for example, that X-rays traveled in straight lines, they cannot apparently be refracted or reflected, they do not carry an electric charge, and they possess the property of ionising or imparting temporary electric conductivity to some forms of gas. It was also found that the X-rays wave length was from 2 to 12 A.U.[1], these rays being somewhat longer than the radium or gamma rays and much longer than the cosmic rays, although these latter rays were not discovered until a later period.

The study of the X-rays still occupies such a prominent position in physics and in medicine, and has led to such momentous results in a variety of directions, that it is difficult to realize that it is only 40 years ago that the rays were discovered by Professor Röntgen, and that it was only just prior to the world war that a long controversy as to their nature was stilled.

We now know that the X-rays are another manifestation of radiant energy, of which visible light and heat are familiar examples. Indeed, the X-rays resemble light rays in almost every particular, the chief difference being that the X-rays have wave-lengths about 2000 to 3000 times shorter. It was this very minuteness of wave length, that defeated all early attempts to direct and sort out the rays. All of the man-made, highest quality, polished surfaces were found to be inconceivably rough for such scientific purposes, and it was not until nature herself was found to have provided an instrument of the requisite delicacy,—in the shape of crystals which can be made to function as diffraction gratings,—that scientists began to analyze and sort out X-ray beams with much the same ease as in the case of visible light.

There are further parallelisms between X-rays and light rays. For example, it is known that the spectrum of a luminous body consists, under suitable conditions, of white light, *i.e.*, a mixture of all visible wave lengths; superimposed on which are certain spectrum lines whose wave lengths are characteristic of the radiating material, for instance, the D lines of sodium; the H and K lines of calcium, etc. In just the same way an element when caused to emit X-rays, not only gives out general radiation, by which is meant a continuous spectrum of wave lengths, but under suitable conditions impresses its own characteristic lines known as K, L and M, on the general radiation. It should be added, however, that the X-ray spectrum of an element is much simpler than its light spectrum.

C. C. K.

---

[1] Koch, C. C. Angstrom Units. Amer. Jour. of Optom. Vol 10, No. 3, pp. 106-110. 1933.